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FROM SWAT TO THE GORGES OF THE INDUS

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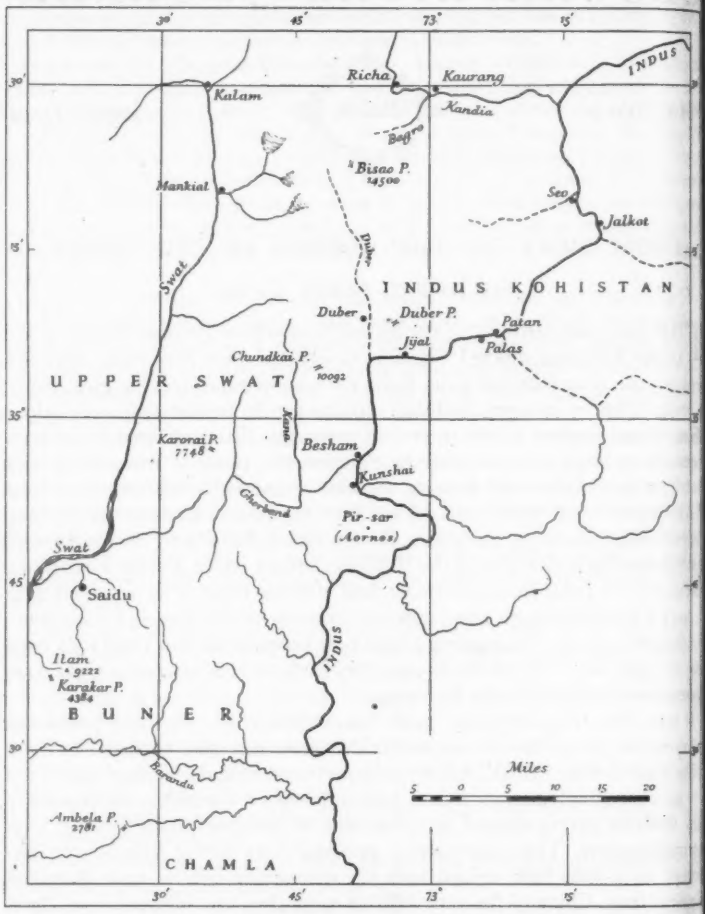
THE mountain territory on the Indian North-West Frontier known as the Indus Kohistan which I was able to explore since November 1941 lies between the river that has given India its western name and the great valley of Swat. This by its many Buddhist remains and by its historical associations offers special interest to the student of antiquity. There in Swat I had been fortunate enough in years past to examine the ruins of many important Buddhist sanctuaries and to trace the sites connected with famous exploits of Alexander. And whenever I set out from my base in Kashmir for my long Central-Asian journeys, my routes, though varied, had always led me through that fascinating high region of the Hindukush range which divides the extreme north-west of India from innermost Asia. On the third of those expeditions in 1913 I passed through Darel and Tangir as the first European to visit those Hindukush valleys. On crossing a high pass between the two I had then been able to sight from afar the deep-cut valley of the Indus where the great river issues down into the Indus Kohistan.

It was then tribal territory, quite inaccessible at the time and practically unexplored. It was known that within that mountain area, bordered by Swat in the west and the British District of Hazara in the east, the Indus, compressed into an exceedingly narrow course, passes through a continuous succession of very difficult gorges flanked on either side by the precipitous faces of high mountain spurs. This information, gathered from native sources and imperfect as it was, fully agreed with the description left by early Buddhist pilgrims from China of the very difficult route they had followed from Darel down the Indus on their way towards Swat. The forbidding character of that route is strikingly reflected by its designation as the "route of the hanging chains" under which early Chinese Annals know it.

All this had made me ever since very eager for a chance of exploring the Indus Kohistan and of following also through the Indus gorges the footsteps of those old Chinese travellers. But I had to wait a very long time for that chance. I owe it solely to the present ruler of the Swat State, Wali Miangul

Gul-shahzada Abdul Wadud Sahib, having completed the annexation of th
Indus Kohistan east of the Indus in 1939.

My recent expedition started from Swat and was carried out under th
auspices of its ruler. So I may refer here briefly to what my renewed visit t
the State he created has shown me of the results achieved there by his rul



Swat is a large mountain territory very fertile in its main portion and bless
with many favours of nature. The old Chinese pilgrims have much to t
about the prosperity of the country, the many Buddhist sanctuaries an
monastic establishments maintained by its population. But after the invasi
of the White Huns in the sixth century A.D. a decline set in. Since its conque
by Pathan tribes and probably also earlier in Muhammadan times Swa

never ceased to suffer from internal feuds uncontrolled by any central authority.

In the famous Akhun of Swat a great religious leader arose in the first half of the last century. He was able to unite the tribes in fanatical resistance to the Sikhs and later to the British regime on the Frontier. But internal disorder remained and exposed Swat to aggresion by powerful neighbouring chiefs. It was only since the present Wali, a grandson of the great Akhun, had established his control over all the tribal factions, and after prolonged struggles had overcome outside aggression, that Swat has enjoyed peace and order. Under the old Pathan custom all lands held by a tribal sub-section or clan had to be divided afresh every four or five years among all the tribesmen. This custom would not allow of any lasting improvement of the land, such as planting fruit trees, for which Swat is suited. It required wise statecraft and persistent effort to stop this traditional system and replace it by individual holdings. Now I could see everywhere flourishing orchards and other improvements as I passed up the road last October to the Wali's capital, Saidu Sharif, where his grandfather's sacred tomb stands.

From the start the Wali had realized the importance of roads both for trade and military operations. So by 1926 I had already found regular mule-paths made under his orders up the main valleys and over the hill ranges between them. Now I found regular motor roads leading up the main Swat Valley and across the large tract of Buner south of it. A very noticeable increase in the number of shops, in the traffic along the roads, and the growth of some villages into something like market towns afforded striking proof of the benefits which security and peace established under a strong rule had brought to a once turbulent country. It was reassuring to find that so much material advance had been secured without changing the simple methods of an administration based on traditional customs, and as regards justice on Islamic law.

The Wali, though now well above middle age, is still as alert and hard-working as I remembered him. He is quite illiterate. But great personal ability coupled with a remarkable memory and wise trust in two very experienced ministers, brothers and supporters in his initial struggles, enable the Wali to direct all affairs. Telephone lines to the most distant posts permit him to gather information and give orders. He has never failed to maintain very cordial relations with Government on the Frontier.

In the summer of 1939 the Wali, after careful preparation, rounded off his dominion by the occupation of the Kohistan valleys between uppermost Swat and the Indus. The difficulty of access and to some extent the barrenness of the ground had kept Pathan tribal settlement away from the Kohistan and allowed the original population of Dard race and speech to survive there. But just as before in Swat, insecurity and internal disorder had caused the scanty population to remain in a very backward condition.

After this last extension of the Wali's rule Colonel W. R. Hay, then Political Agent for Dir, Swat, and Chitral, informed me that the opportunity for exploration in the Indus Kohistan had come within my reach. When after my return to India in 1939 I learned that the Wali desired a postponement of my expedition I did not feel discouraged, for I knew that the goodwill

and judgment of my old patron could be trusted. Last September I learne that the Wali was now prepared to let me start after the Ramzan, the mont of Muslim fasting, had passed by the close of October. That area ha remained the only practically unsurveyed ground along the whole course o the Indus from Tibet to the Arabian Sea. So Brigadier E. O. Wheele Surveyor-General of India, readily agreed to depute with me Surveyo Muhammad Ayub Khan, who had been my survey assistant on all my fou Persian expeditions.

A few days' stay at Peshawar under the hospitable roof of Governme House allowed me to thank Sir George Cunningham, Governor of the N.W Frontier Province, for the friendly interest and help with which he has a always furthered my plans. On the Malakand I could thank Colonel E. G Mallam for what he had done as Political Agent to smooth my way. A Saidu, the capital of the Swat State, I received the kindest welcome from th Wali. A motor drive of some 120 miles across the Karakar pass and the wil tracts of Buner and Chamla allowed me to visit again the famous Ambe pass.

On October 30 I started with my little party for the Indus Kohistan. Th route led up the Kana valley down which I had passed in 1926 on my wa to Alexander's Aornos. To reach its mouth by a motor road just complete saved what at that time would have meant a week's travel. On the way up th Kana valley and for two marches beyond it was still possible to use mo transport. But farther on during nearly three months' travel we had t depend on porters and our own feet. It was pleasant to find my passage st well remembered by the old Khans of Kana.

Then from the head of the Kana valley overlooked by high snowy pea the ascent led to the Chundakai pass. On its top, about 10,000 feet abo sea, we were received by Hakim Abdul Qudus, Governor of the Kohista who was to accompany us through our difficult travels. It was due mainly t his unfailingly careful arrangements that all the physical difficulties were suc cessfully overcome.

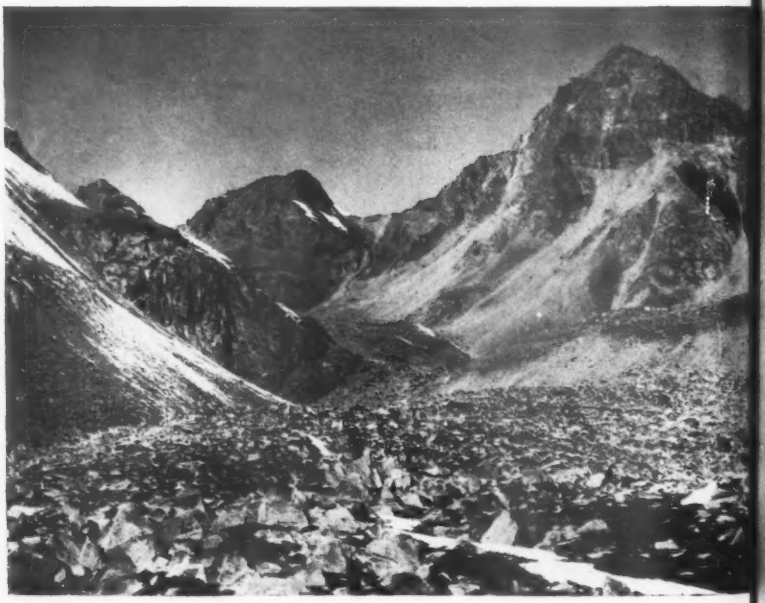
The route chosen for the first marches led along high alps at the head o very narrow valleys descending steeply towards the Indus. From camps ne the tree limit it was possible to climb several high spurs, which provide excellent stations for the exact plane-table survey carried along the whole o our journey. They commanded distant views to the north-east and eastwa across the Indus valley and beyond it as far as the snowy ranges which divi the Kohistan from Kaghan and Kashmir territory. But the great river in i deep gorges was completely hidden.

When our route had led us down into the side valley of Duber our cam was pitched for the first time under the walls of one of those picturesq timber and rubble-built forts which shelter the Wali's small garrisons in th Kohistan as elsewhere in the State. By their uniform plan they curiousl recalled to me those ancient Roman *castella* by which the Roman Empire fo centuries guarded the *Limes* routes on its Near-Eastern frontier. The Wali' men-at-arms holding those forts assure order in a previously lawless countr The men as well as their officers and the few local officials are all paid in kin from the *ushar* or land tax, amounting to one-tenth of the actual produc

The Wali of Swat at Saidu

Gabrial fort and Kandia river

Glacier on range south-east of Bisao pass



Towards Bisao pass from Lal Bek

Such an impost, spent almost wholly in the valleys where it is levied, does not weigh heavily on the local population, poor as it is. The cultivable ground all through the Kohistan is extremely limited; hence its people depend far more on their cattle and goats.

From Duber it was necessary to gain the Kandia valley northward, the only side valley of any size. The Bisao pass, which gives access to it, was likely soon to be closed by snow. It was crossed just in time, but proved trying. After a long march had brought us to the highest of the huts to which the Duber people, like all the others of the Kohistan, repair in the summer for grazing, it took us a day and a half of exacting climbing before the height of the pass was gained. The ascent on the first day lay over a succession of old glacier beds and moraines. The recession of glacier ice, apparently not very distant in geological time, had left here huge masses of rock debris in utter confusion, very trying to the feet, especially to mine, which had lost many toes from frostbite thirty-four years before on the high Kun-lun range. It was long after darkness had set in that the narrow rocky ridge was gained where room could be found for a night's halt.

The morning light revealed an amphitheatre of rugged peaks crowned with *névé* beds and small hanging glaciers. The Bisao pass is formed by the knife-edge *arête* of a rocky spur running down steeply from a great massif with peaks close on 19,000 feet high. In order to gain our way to it we had to scramble up a long series of old terminal moraines. They looked like huge steps laid down by a former great ice flow. From the pass for which aneroid and clinometer observations indicated an approximate height of some 14,500 feet, a wide snowy trough was seen to descend northward. The descent in soft snow hiding detached masses of rock was necessarily slow. So it was quite dark by the time the head of a steep and narrow ravine was gained in which the further descent had to be made. The sides of the ravine were covered with deep snow, and the descent along a very precipitous slope in the light of a lantern looked risky. By the time it had been safely accomplished Surveyor Muhammad Ayub and myself had been six hours in the snow. Three more hours were needed to bring us to the first place where it was possible to camp with some shelter for the load-carrying men. By then it was one hour after midnight.

After that long day's experience the three marches which took us down the Jagro valley to the Kandia river seemed delightfully easy. But we had not yet covered the second when fresh snow was seen falling on the high mountains above. It meant the closing of the Bisao pass until the next summer. At the little village and fort of Karang in the centre of the Kandia valley a halt was imposed partly by survey work and partly by the illness of one of my two old Kashmiri servants. At first it looked serious. But Surveyor Muhammad Ayub was able to proceed up the head of the Kandia valley and in spite of trying climatic conditions to check his position by observation on distant triangulated peaks. Once assured about my servant's condition I followed him to the last small village of Kandia. In ascending the deep-cut gorges of the river difficult cliffs rising high above the rock-bound bed had to be negotiated. As at Karang, so also at the hamlet of Richa I found that old mosques in the designs of their wood-carving showed motifs unmis-

takably derived from the style of Graeco-Buddhist sculpture. It was impressive evidence that the influence of Hellenistic art had penetrated into this far off mountain region in spite of the very rude conditions of life there.

From the head of the Kandia valley we turned back to reach the gorges of the Indus. But before we arrived there bad weather with rain and snow overtook us at the fort of Tuti which guards the approach from the Tangir side. It was a bad place to get weather-bound in. The Kandia valley is there so narrow that Tuti is never reached by the sun for three months of the winter. Fortunately it was possible to use such enforced halts for some record of specimens of the little-known Kohistani language. It belongs to that Dardic branch of the Indo-Iranian language group which is now confined to Hindukush valleys but in earlier times was spoken much farther down the Indus. How the tribes still speaking Dardic languages came to occupy these high mountain tracts is an interesting problem. For its elucidation anthropological evidence is much needed. In order to help towards securing it anthropological measurements and observations were taken on a considerable number of Kohistanis in the course of my journey.

On December 11 at last we could leave gloomy Tuti and descend the Kandia valley to the Indus. For a couple of miles the difficult track lay mostly over galleries clinging to sheer rock faces and supported by tree branches, before the first view of the Indus was gained from a height of some 1000 feet above where the Kandia river joins it: the Indus a narrow band of intense ultramarine green confined to a rock-bound bed between precipitous mountain sides. The track which had brought us to this point, and which we were to follow farther on, had been much improved under the Wali's orders since the occupation of the Kohistan, and for this great credit was due to the Hakim. Even thus it has remained difficult enough and quite impracticable for any laden animal. On the opposite left side of the river the track still in use by the people living east of the Indus clings in places to bare rock walls along narrow ledges, with tree trunks serving as ladders to connect them.

That early Chinese pilgrim, Fa-hsien, has described the forbidding route he and his pious fellow travellers had followed in A.D. 400, after leaving Ta-li-lo, the present Darel. In Professor Giles' translation it runs: "Keeping to the range, the party journeyed on in a south-westerly direction for fifteen days over a difficult, precipitous and dangerous road, the side of the mountain being like a stone wall ten thousand feet in height. On nearing the edge, the eye becomes confused; and wishing to advance, the foot finds no resting place. Below there is a river, named Indus. The men of former times had cut away the rock to make a way down, and had placed ladders on the side of the rock. There are seven hundred rock steps in all; and when these and the ladders have been negotiated, the river is crossed by a suspension bridge of ropes. The two banks of the river are somewhat less than eighty paces apart . . . Having crossed the river, the pilgrims arrived in the country of Udyana (Swat) which lies due north of India." This description is now fully confirmed by our survey. We have here one more proof how much reliance can be placed on the topographical sense and power of observation of those old Chinese travellers on whose records the historical geography of India so largely depends.

Indus at confluence with Kandia

Indus above Sio

Indus above Patan

Indus near Kunshai

Our progress down the Indus during the next few weeks showed only too early what was meant by Fa-hsien's reference to those many "rock steps," s the translation puts it. On all the eleven trying marches which took us own to where we turned off from the Indus to follow the route up the horband valley to Swat, there was daily a constant succession of tiring scents to be made. The track climbs up steeply ridge after ridge, each rising metimes as much as 1000 feet or more above the river, in order to avoid im- ssable cliffs. From the heights thus gained there were invariably descents, ften quite as tiring, to be made again towards the river. Nowhere was it ossible to keep for any distance near to the river bank since masses of huge oulders line it wherever the river does not actually wash the foot of impass- le rock walls. I have not counted all the climbs, but they must have been ill more numerous before the recent track was constructed. When this was eing made the men had often to be suspended from pegs while they were at ork boring holes to blast the rock or to fix in fissures the tree branches which ere to support galleries.

This is not the place to give details of the arduous marches which carried down the Indus to where the great river leaves its gorges. In comparing e number of our eleven marches with the fifteen counted by Fa-hsien it ust be remembered that his reckoning starts from the mouth of the Darel lley, at least 30 miles higher up than that of the Kandia valley.

Throughout the Kohistan the route along either bank of the Indus retains very trying character. Only at a couple of places, at Sio and Patan on the ght bank and Jalkot and Palas on the left, alluvial fans, small in size, leave om enough for settlements deserving to be called villages. But owing to the eat summer heat of the narrow Indus valley even these villages with their sely packed rows of low rubble-built dwellings are occupied only during e cold weather months. For the rest of the year their inhabitants retire th their cattle and goats to huts on high grazing grounds.

It is the same with the few hamlets to be found at rare intervals along the er. The mountain sides to which their dwellings and small terraced fields ng, everywhere hundreds of feet above the Indus, are so steep that patches flat ground for pitching our little tents could be found only with difficulty. e conditions of life among the scanty population, with its extremely limited onomic resources, could not have been very different in ancient times. At e few old village sites reported the ruined dwellings examined proved as le in construction as those inhabited at the present day. Yet the great size the trees, mainly Ilex, growing over the ruined walls proves considerable for the occupation of these sites.

Owing to the depth and extreme narrowness of the valley in which the dus has cut its bed through the mountains, it was not possible from our te to sight any high peaks already fixed by triangulation over great dis- ces, but at last Muhammad Ayub, ascending the side valley of Patan to highest of the summer huts, reached from there positions on high snow- ered spurs which could be fixed on the plane-table; the position thence duced for the fort at Patan was less than a mile and a half from that pre- usly indicated by his traverse.

These survey operations and other tasks had necessitated a longer halt

at Patan. It allowed Hakim Abdul Qudus to attend to arrears of work at his headquarters there; but it subsequently caused us to be overtaken again by bad weather conditions at two further stages down the Indus. At the fort of Jijal the days of continuous rain mingling with snow were distinctly trying, for the terrace specially raised to provide some level space for our little camp was soon turned into the semblance of a morass, threatening to glide down the steep slope.

Near Sio and at a few points lower down the width of the great river could not much exceed 40 or 50 yards. Near Sio and again below it near the village of Jalkot on the left bank we were shown places where the Indus had been spanned by rough wooden bridges in quite recent times. The great depth of the water in the narrow bed, even in its reduced winter flow, accounts for the beautiful green colour throughout its course, except where rapids break in white waves. The great height and much increased width to which the river rises during the floods of the spring and summer could be judged by the water-worn appearance of the cliffs and the huge boulders to be seen on either side high above the narrow rock-bound bed.

By the third week of January we emerged near Besham on ground already mapped by the Survey of India at the mouth of the Ghorband valley. Only a couple of miles below must have been that rope bridge crossed by Fa-hsien and his fellow pilgrims. There close to the village of Kunshai the Indus flows in a rock-lined bed about 80 yards wide, closely adjoined on either side by steep equal eminences high enough to allow the rope bridge to hang well above the river even when in flood. On the rocky ridge of the right bank are remains of an ancient watch post to guard the bridge and the passage.

Here our exploration came to its end, but not yet the difficulties of travel. The Ghorband valley farther up was under snow right down to its bottom, and when after three marches we had approached its head the Karorai pass covered with exceptionally heavy snow presented a serious obstacle. But plentiful local help and a favourable turn of the weather allowed us to cross the pass safely, though not without some difficulty. Then the wide open Swat valley lay before us, and soon after being very hospitably welcomed at the Wali's residence I could thank my old patron once again for all that his unfailing support had allowed me to do and enjoy in pursuit of a long-cherished plan.

The sketch-map to show the outline of this journey has been made from Survey of India Half-inch sheet 43 *F/NW, Quarter-inch sheets* 43 *A, B, and E, and* 1/*M sheet* 43 *dated* 1935, 21, 34, 35, *and* 30 *respectively: the latest we have in our collection. It cannot show all the names mentioned by the author because some are not on these maps. Where his spelling differs from the Survey maps we have retained his spelling in the text, and left the Survey spelling on the sketch-map. Sheet* 43 *B shows a number of unmetalled roads and tracks as "fair weather motor roads," but it is not possible to select those which have now been improved and made the main road to Saidu, the route of the author's trip to the Ambela pass, or the road north and east of Saidu to the Kana valley.*

SURVEY BY HIGH OBLIQUES: THE CANADIAN PLOTTER AND CRONE'S GRAPHICAL SOLUTION

CAPTAIN L. G. TROREY, R. Canadian Engineers

Meeting of the Society, 8 December 1941

PEOPLE who have any connection with air survey, particularly with the photogrammetric end, seem to become affected in much the same way as are users of habit-forming drugs. These unfortunate persons can be recognized in the early stages of their affliction by a peculiar glitter in the eye. They say it is due to long hours of peering into stereoscopes, and so on. But that is not the truth. It is the first symptom that the photogrammetric virus is at work. In later stages these people have an irresistible impulse to read a technical paper, and in really serious cases they design a photogrammetric instrument. For these reasons, in the technique of the art of photogrammetry there are more hard ways of doing easy things than in any other branch of human endeavour.

Two exceptions which go to prove the foregoing rule are the Crone Graphical Construction, and the Burns High Oblique Plotter. In previous times the surveyor used to climb mountains, often with considerable exertion, and then sit on the mountain top waiting for the weather to clear so that he could take observations. Later, he used a combination of theodolite and camera, but still had to climb the mountain with it. Now he flies, takes some pictures, and does the observing comfortably in his office. Still better, he sends someone else to take the pictures, and does not go out at all.

The High Oblique Plotter and the Crone method do all that could be done if you imagine some means of holding a plane still in space while you set up a theodolite on it and make the observations. There are two limits to bear in mind: the field of view is that of the camera, and the accuracy of a precise theodolite would not be expected.

Air survey photographs

Air photographs may be taken with the camera axis pointed vertically downward, in which case the picture, under certain conditions, approaches to being a true plan of the ground below. These are verticals, and are familiar nowadays to most people.

If the camera axis be deliberately pointed off the vertical, an oblique photograph results. High Obliques are those in which the horizon appears, or nearly appears. Horizon Obliques is a better name. When the inclination of the optical axis to the vertical is less than that required to contain the horizon, but too great for the picture to be treated as a vertical, there results a Low Oblique. Low obliques, particularly those just too tilted to be called vertical, are also referred to as Near Verticals.

Verticals and near verticals require to be controlled; that is to say we like to know the map position, and the elevation, of several points on each picture, or at any rate several points on the flight. From horizon obliques we may obtain the azimuth from the plumb point (the point immediately below the

lens at the instant of exposure) to any picture point. Thus, if we know the map position of three or more image points, we may resect the plumb point and, with an overlapping series of photographs, extend a triangulation network over considerable distances.

Vertical angles also may be measured from the photographs and elevations carried. In fact, one can perform any survey operation from high oblique photographs that could be performed by a theodolite set up at the point of exposure.

There are many methods which may be used to determine these angles. For our purposes we require one which is rapid and accurate, and it must be such that ordinary personnel, perhaps with little previous technical training, may be taught its use and become manually skilled in its application in a short time. Tests of these methods, with the above ends in view, led to the conclusion that the High Oblique Plotter and the Crone Construction fulfilled the requirements. The specific object of this investigation was to compare the two methods, and to measure their accuracy when used by personnel previously unfamiliar with them. Sets of observations were made on each of about one hundred angles, but before discussing these results a brief description of each method will be given.

The Canadian High Oblique Plotter

This instrument, designed by Brigadier E. L. M. Burns, is simple in principle, construction, and operation. Briefly, it is a theodolite set up at the

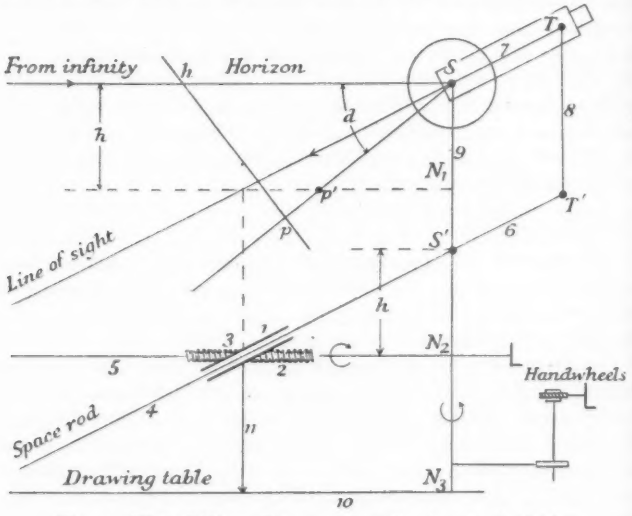


Fig. 1. High Oblique Plotter: elevation in principal plane

perspective centre. Fig. 1 shows the arrangement diagrammatically in an elevation of the principal plane.

The instrument is set up so that *Sp* is normal to the photo *ph*, and passes

The Canadian High Oblique Plotter

Crone's graphical solution: HNM is the angle at the plumb-point between and the principal plane

between

rough its principal point when the angle hSp is equal to the depression angle making pS, which is adjustable, equal to f, the focal length of the camera. T is a telescope pivoted at S, and having a vertical circle at S. It is evident at if the telescope be directed at any image point, the line of sight will intersect e ground at the actual object photographed. Imagine an auxiliary plane N_1p' shown. The trace of the line of sight on this plane would be a point homoous to the ground point at the scale H of plane divided by h of Fig. 1. The rallel motion 6–7–8–9 moves the auxiliary plane to N_2 at distance h below S'. e space rod 6–4 therefore duplicates the motion of the line of sight as it scans e photograph. The pieces 1 and 2 are pivoted at 3, the space rod slides in while 5 is a long worm to which 2 is threaded. Rotating 5 then moves 2 and e whole parallel motion rotating the telescope in a vertical plane. Motion in imuth results from the rotation of SN_3 by means of gearing not shown, a rizontal circle at N_2 measures the rotation. These motions are transferred to e drawing-table 10 by the pencil 11. Thus as the telescope scans a piece of tail, a true plan, scale h/H is traced on 10 provided no ground relief exists.

easurement of azimuth and depression

The preferred application of the machine is to determine azimuth and pression angles in rough terrain. The picture being oriented as explained, d the telescope TS directed at an image point, azimuth and depression are d on the horizontal and vertical circles. Setting pS to an equivalent focal gth to compensate paper distortion, angles may be measured as well as by imilar theodolite on the ground.

When a calculated resection is not desired, TS is directed at the image of a ntrol point. Rotation of 5 moves the transit in a vertical plane containing e plumb line SN_3, hence 11 moves radially to the plumb point, actually wing a ray from the plumb point N_3 in plan. The method of the preding paragraph was used in the investigation.

ill for setting up the High Oblique Plotter

1. Determine equivalent focal length by measurement on the fiducial rks and set pS to this value. Where differential distortion exists use the quivalent for azimuth and the y equivalent for depression. This expedient ot mathematically precise, since x and y enter into both angles, but the or introduced is negligible.

2. Draw the principal vertical on the print and determine the depression the optical axis, or if necessary use the Crone Construction to obtain the e horizon.

3. Set the vertical circle to read d and adjust the photo plate and azimuth ndwheel until the x-hairs intersect the central punch mark on the plate.

4. Set the photograph on the plate with the principal point on the x-hair ersection, aligning the principal vertical along the vertical hair.

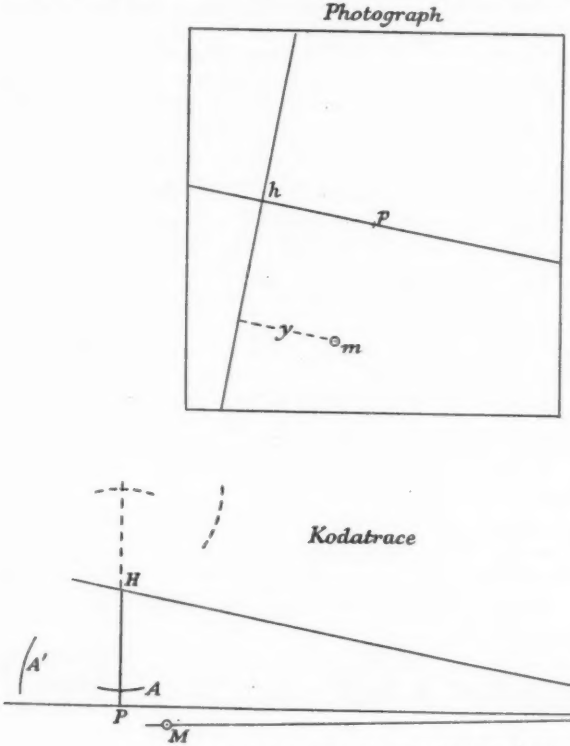
5. Swing the line of sight towards the top of the photo, and if the intertion of the x-hairs does not now cut the principal vertical, rotate the plate means of the plate tangent screw until it does. Swing to p again as a check. e set-up is now complete, and the azimuth and depression of any image nt may be read directly off the circles.

6. In 4 and 5 care must be taken not to move the azimuth handwheel from setting obtained in 3.

Crone's Graphical Construction for Azimuth

A rapid and ingenious method of taking off azimuth is described by Major D. R. Crone, R.E., in Chapter XII of the Survey of India Handbook of Topography 1939; an earlier method is described in 'Hints to Travellers,' 11th ed., vol. I. It is of course applicable irrespective of the ground relief. Drill is as follows:

1. On the photograph establish, if possible, the true horizon and draw the principal vertical. If the true horizon cannot be established, draw a



Figs. 2 and 3. Crone's Graphical Solution

trial horizon from the best information available and draw the trial principal vertical at right angles to the trial horizon.

2. On a piece of kodatrace draw *PN*, making $PN=f$ (Fig. 3). Through *P* draw *PH* at right angles to *PN*, making $PH=ph$ of the photograph. Join *NH*.

3. It is required to locate a ray from the ground plumb point passing through the picture point *m*. Set dividers to dimension *y* of Fig. 2, the distance of *m* below the true or trial horizon of the picture. With centre *H*

and radius y strike an arc to intersect HP, as shown in Fig. 3. With centre at this intersection and the same radius, strike a second arc A' *on the side of HP remote from N.*

4. Place the trace on the photograph with NH along the principal vertical and, maintaining this coincidence, slide the trace along ph until the arc A' is tangent to the horizon. Prick the position of the image point m at M. Join NM on the trace. Then NM is the required ray and the angle HNM the true angle at the ground plumb point between any point M and the principal plane.

5. In mountainous country the true horizon may be below the image points of the higher peaks, as when their elevation is greater than the height of the plane. In these cases the sign of y changes, and the arcs A and A' of Fig. 3 will be drawn *above HN* and *to the right of HP.*

Three control points, such as m, being contained on one photograph, the ray from N to each of these may be obtained, and N resected by the ordinary solution of the three point problem period.

Azimuth calculated from measured coordinates

Taking as origin the point where the principal vertical of the photograph intersects the true horizon:

$$\text{Tan } A = x/(f \cos d - (y - ph) \sin d)$$

where A is the azimuth, x and y the coordinates of the image, d the depression of the optical axis, and ph the distance from the principal point to the horizon.

We intended to make a set of observations by this method, with which the Crone and the High Oblique Plotter values could be compared. The coordinates were measured with a steel millimetre scale to plus or minus 0·05 millimetres. It became apparent however that the method was slow and cumbersome and the accuracy of the results so obtained is not sufficient, unless more precise coordinate measurements are made.

Comparison of Crone and H.O.P.

The test procedure for Crone was to draw the construction for about one hundred angles. Two groups of seven men were employed, that the effects of personal errors might be reduced. These men had been given a short lecture on Crone and on the High Oblique Plotter, but had not had previous experience in either method. There was general supervision only, but they were supplied with a printed "drill" showing the various steps of the construction.

It was necessary to measure the Crone angles to compare them with the results obtained by the other methods. At first a 10-inch protractor was used, making the readings with a small hand-lens, but the precision so obtained was insufficient. So the tangent of each angle was measured, using a 10·00-inch base line (along the principal line of Fig. 2) and measuring the offset to each ray. A Gunter's scale and beam compasses were used, and much more satisfactory results were obtained than with the protractor.

These same angles were then read on the High Oblique Plotter, usually by the same men, and before the Crone angle had been determined numerically.

All the tests were made on 5-inch by 5-inch contact prints, the focal length the lens being 8 inches. The angle of the lens is then about 35°, or 47° measur across a diagonal. The horizon was in some cases assumed, and in other ca was the true horizon; the depression of the optical axis varied from 12° to 15° 16°. Points whose azimuth was measured covered a large range of depressi angles, zero to 25°, while the azimuth range was between the extreme corn of the photograph. The range of elevation in the particular area did n exceed 400 feet, but it is emphasized that elevation makes no differen whatsoever in any of the methods used, the effect being to shift the ima towards or away from the plumb point on the same azimuth, as will be se from Fig. 3 for the Crone Construction, and as is evident, for the plotter, fr the description of the instrument.

In the early part of the investigation, covering about half the data, a thi set of observations was made, using the calculation method. It was so apparent that the results had little value in this investigation, and the observations were therefore discontinued.

The azimuths of about one hundred points were measured by the Cro Construction and by the plotter, using the same print and horizon. T average discordance between single observations of the same angle by t two methods was found to be about two minutes of arc. The fifty odd obse vations by calculation from measured coordinates showed substantially t same precision. Both the Crone Construction and the instrument are rap twenty minutes sufficing these comparatively untrained men, on the averag to obtain the azimuth of six image points on one picture. The calculati method is slower, with no compensating increase in accuracy.

It is stressed that the discrepancies measured were those inherent in t techniques themselves, and do not include systematic errors which can ar from incorrect horizons, inaccurate lens calibrations, paper distortion, poi ing errors, and so on, all of which factors were deliberately rendered consta by the conditions of the tests. Also precautions were taken that perso errors did not greatly influence the results.

Conclusions

These data then lead to the following conclusions:

1. For well-defined image points, and using prints from calibrated came the Crone construction will probably draw angles to within two or thr minutes of their true values, when the horizon may be accurately establish

2. That this accuracy does not require any unusual manipulative skill the part of the observer.

3. That since it is unlikely that an angle can be drawn closer than this b any ordinary means, there is no advantage in using the High Oblique Plott where *graphical* intersections are to be made.

4. That where calculated resections or intersections are to be made, when elevations are to be *computed*, the Plotter is superior. This latter co clusion does not follow directly from data presented here, but will be obvio from the principle of the instrument. It may be established by observati of ground control.

5. Since this paper was read we have tested the precision of the Cro

Construction for measuring vertical angles. For reasons which are not at this time apparent, the same agreement was not obtained as with azimuth observations. From the data it is tentatively suggested that the discrepancies may be about twice as great as for azimuth.

DISCUSSION

Before the paper the PRESIDENT (Sir GEORGE CLERK) said: The reader of the paper this afternoon, Captain Trorey, Royal Canadian Engineers, is an officer on the staff of the Canadian Field Survey Company now in this country. Canadian surveyors have always been pioneers with ideas of their own on the use of photography in survey and have brought with them to England a relatively simple machine for plotting oblique air photographs, which will interest us very much. In particular, we shall be glad to know how they combine the use of this mechanism with the beautiful graphical method of dealing with such a photograph which was invented some years ago by Major Crone, of the Survey of India, brother of our Librarian. Captain Trorey proposes to give some account of the theory of the two methods and will then be glad to demonstrate the use of his machine to all interested inquirers.

Captain Trorey then read the paper printed above, and a discussion followed.

The PRESIDENT: It has been, to an ignorant layman like myself, an extraordinarily interesting paper. We are fortunate in having present really great experts on the subject, Major-General MacLeod and Colonel Fryer. I hope that they will take part in the discussion and illumination of the subject.

Major-General W. N. MACLEOD: I do not think there is any need for me to discuss the instrument, but I would like to thank Captain Trorey for his description, which I found very clear indeed. I am looking forward to an opportunity of examining the instrument.

The PRESIDENT: Perhaps Colonel Fryer would like to comment on the paper.

Colonel FRYER: Might I ask Captain Williams to start the ball rolling?

Captain W. W. WILLIAMS: There are one or two questions I should like to ask, but let me first express our thanks to the Canadians for bringing over a simple instrument which does away with the tilt distortion and relief distortion so worrying in photogrammetry. In the paper we have had presented to us two methods of which we should take full advantage. I feel that many of us having listened to the paper will go away with the intention of following it up. I believe the method was available first of all for use in British Columbia, where the mountain tops were probably, the same as the triangulation points, perfectly clear. I would like to know Captain Trorey's experience in using a method over country where we have not such characteristic control: for instance, in the Salisbury Plain country or, a little farther afield, in the Libyan Desert.

Captain TROREY: I am afraid I cannot answer that question fully. We are now carrying out some work of that nature, but we have not as yet any figures and results.

Captain WILLIAMS: The second point that interested me was the ability to photograph and measure angles to 2 minutes of arc. The table shown was very convincing. There is the horizontal limitation, the smallness of the angle itself. The fixed angle I saw was 11° odd, but we know the limitation of that is from the angle of the camera itself. I should like reassurance that measuring these angles to about 2 minutes of arc is within the power of the ordinary draughtsman.

Captain TROREY: I can say in answer that no great skill is required. I have

here some further tests, the work of a man using the Plotter, and the Crone construction, for the first time. His discordances are of the order of one and half minutes of arc. The man is not a draughtsman, he had had about ten days' training in photogrammetry.

Captain WILLIAMS: I should like to know the relative speed of the two methods up to resecting the plumb position of the camera station on the plotting machine; the resection, say, to one point on the plotting sheet from the Crone method and doing the same by mounting the photograph, sighting it to the horizon, tilting, measuring the same angle and plotting it. I do not know whether you have made tests on those lines.

Captain TROREY: Yes, we have. We have standardized the maximum time allowed for a complete Crone resection at thirty minutes per photograph, raying six points. A good man can do it in twenty minutes, the same man using the Plotter takes about fifteen minutes.

Colonel FRYER: I am no air survey expert. Colonel Hotine, who is one of the greatest living experts, has just escaped from the hall, but I should like to take this opportunity of acknowledging the extraordinary help we in the British service are receiving from the Canadian Survey Company.

Perhaps for a moment to get back to earth, I would like to ask why are we considering this problem to-day in the middle of this war? The answer is, I think, that in the Army we have now to consider several different types of photograph that the Air Force give us to assist the man on the ground who has got to fight. We may get verticals, which we like best. We may get near verticals, high obliques, and low obliques. We are all grateful to Captain Trorey and his colleagues who, because of their skill at this work, are ever seeking out new methods to help us to transfer from the photographs we get from the Air Force all the detail that they can add to the map which we are going to give to the chap who is going to fight. I think that is the whole object of what we have been discussing to-day.

When we think of these technical things, we nearly always get involved in rather large and cumbersome instruments. We have one before us. Whenever we do that I suggest in all these things it comes back to bed-rock, of how we are to carry these instruments. We have in the Army certain tables laid down in regard to our stores, known as AF/G/1098, a well-known number in the Army. We have a certain number of lorries, trucks, and so on, to carry these things in. First of all, the Canadians come along and say they have invented an absolute cat's whiskers for this type, and they produce that instrument which weighs—I do not know how much.

Captain TROREY: A considerable amount.

Colonel FRYER: Then somebody asks me for the boxes to put the instrument in. Then comes the question of where we are going to put it. You would be surprised what a trouble it is when anything new is invented to find where to put it and how to carry it. We have not even now all the lorries we want. And so we have to temper these things. I do not know whether that is the answer between the Crone construction and the method of plotting described to us. I am not sufficiently technical to be able to say, but I do feel we have to think down to bed-rock in these matters when trying to keep the object in view.

Captain Trorey has this morning in my office shown me another gadget which I think is going to help us very much in the Survey Companies in dealing with oblique photographs. I should like to join in thanking Captain Trorey for all he has told us this afternoon.

THE MAP OF THE PACIFIC

Discussion opened by COLONEL SIR CHARLES ARDEN-CLOSE

Meeting of the Society, 13 April 1942

THE PRESIDENT (Sir GEORGE CLERK): There is no need for me to introduce Sir Charles Arden-Close to the Fellows of this Society, so I at once call upon him to open the discussion on the Map of the Pacific.

Sir CHARLES ARDEN-CLOSE: All of us have very much in our minds recent events in and near the Pacific Ocean, and many must have turned to an atlas to see the relative positions of the battle fronts and the distances involved. This discussion has to consider the useful ways of mapping that great Ocean, and in particular the choice of suitable projections.

The Pacific is approximately twice the size of the Atlantic, about 60 million square miles. Its breadth, along the Equator, from near Singapore to the coast of South America, is about 177°; and its meridional length, along the anti-meridian of Greenwich, is some 140°. If it is required to show the relation of Ceylon and the eastern coasts of India to the islands of the Pacific, we must take in 200° of longitude: a pretty problem for the cartographer.

We do not use an atlas map for any minutely accurate measurements; the chief value is to give us the relative positions of land features, and distances, areas, and shapes. We leave it to the expert to plot great-circle courses, or to calculate exact distances. In fact, we want a general picture, and our main problem is, given the immense stretch of the Pacific Ocean, to choose projections for its representation.

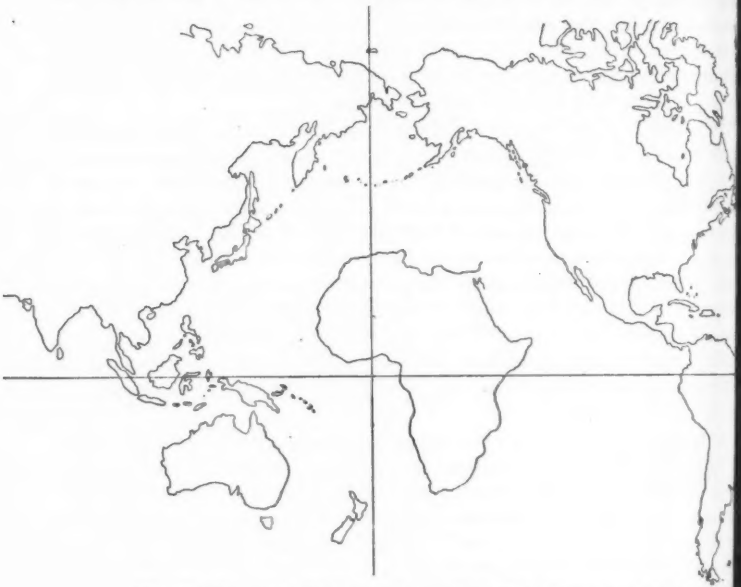
The makers and publishers of modern atlases and single-sheet maps nearly all plot the Pacific, or Oceania, on some equal-area projection. Philips' Mercantile Marine Atlas, Bartholomew's Citizens' Atlas and Oxford Advanced Atlas use the Sanson-Flamsteed Equal-Area Projection. Meyers' Grosser Hausatlas, the atlas of the Italian Touring Club, and Philips' Senior School Atlas use, or seem to use, the Zenithal Equal-Area Projection, the latter employing it for maps of the Eastern and Western Hemispheres. Stanford's Map of the Far East and the Pacific Ocean is on Mollweide's Equal-Area Projection.

All these Equal-Area Maps do, from the nature of their projections, give true ideas of areas, and fair representations of distances across the ocean, though shapes suffer towards the margins. Some of them are beautiful maps. If we were limited to the choice of one type of projection, I, for one, would jump for an equal-area projection, and I should be in good company.

There is one important single-sheet map of the Pacific which is drawn on Mercator's Projection, namely, The Theater of War in the Pacific Ocean, published by the National Geographic Society of Washington. It exemplifies the merits and demerits of this projection. Its extent in longitude is 200°, and the scale along the Equator is 1 to 35 million. On this projection, Southern Alaska, along latitude 60°, has a scale twice that along the Equator, and the areas are four times as great as those on the Equator. We get the very familiar, and very incorrect, impression of huge areas in the North. We cannot

measure, even approximately, distances across the Ocean. But, of cour
local configurations are correct, and each meridian is as good as any other.

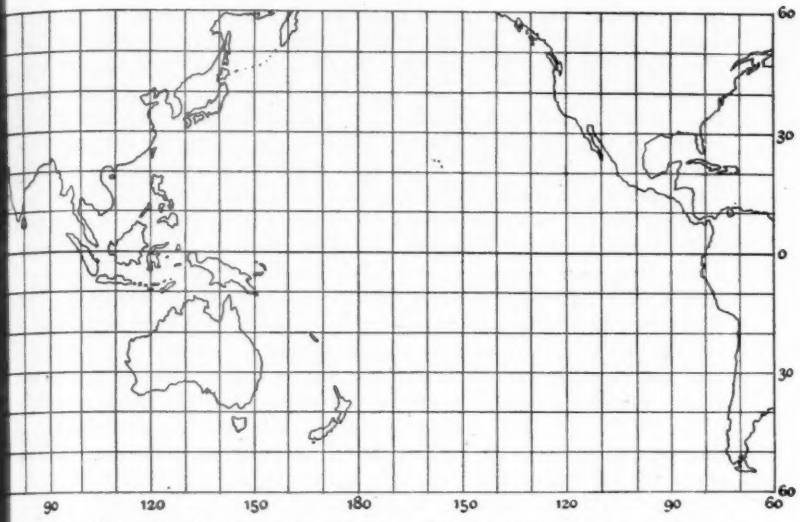
But we are not limited to equal-area projections, or to Mercator's, in o
representation of the Pacific. There are several Cylindrical, and Pseud
Cylindrical, Projections, which have some merits for the purpose. And, fi
may be mentioned that ancient square projection, the *Plate Carrée*. I ha
shown, elsewhere, that this projection is, for 50° each side of the Equa
sensibly the same as the mean between Mercator's Projection and t
Cylindrical Equal Area. As compared with the "undiluted" Mercator



The Pacific, with Africa inset, on the 'Plate Carrée' projection

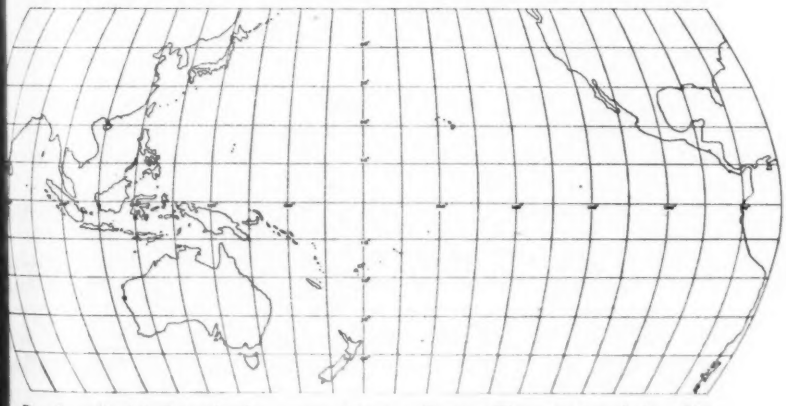
chief advantage is that areas in the south and north are not so grossly exag
ated. It is the easiest of all projections to draw.

There is another almost equally simple cylindrical projection which
give a rather better representation of the Pacific, namely, the Simple R
angular Projection. In this, in place of an assemblage of squares, we dra
assemblage of rectangles. It is the limiting case of that well-known sy
the Conical Projection with Rectified Meridians and two Standard Paral
and we can choose which parallels shall be made true to scale. As an exa
I have drawn a projection in which the parallels 30° North and 30° South
true to scale, the meridians being everywhere their true lengths. The Equ
will now be too small by about 13 per cent., and the parallels 40° N. and 4
will be too large by about the same amount. The general picture of
Pacific is good, particularly between 40° N. and 40° S., say from San Franc
to Melbourne.



The Pacific on simple rectangular projection, with parallels 30° N. and S. true to meridional scale

It is now necessary to mention the group of Pseudo-Cylindrical Projections as being possibly useful for our purpose. The introduction of this group seems to be chiefly due to Eckert and Winkel. Perhaps the simplest of these



Pseudo-cylindrical projection, mean between Sanson-Flamsteed and the 'Plate Carrée'

is the arithmetic mean between the square *Plate Carrée* and the Sanson-Flamsteed. In this projection the parallels are straight lines parallel to the Equator, at the correct spacing on the central meridian. The distance of any

other meridian from the central meridian is a mean between the equatorial distance and the true distance at the particular parallel in question. This distance is thus equal to $\lambda \cos^2 \frac{1}{2}\phi$, where ϕ is the latitude and λ is the longitude measuring from the central meridian. The meridians are now curved lines. There is no undue distortion; in the example shown, the error of scale on the extreme parallels is about 28 per cent., and along the extreme meridians, in the corners, about 25 per cent. An improvement can be made by taking as errorless some parallel other than the Equator, say, 30° N. and S.

There are two more projections which ought to be considered, and each of these has a circular boundary. The projections are, Clarke's Minimum Error Perspective Projection, and Airy's Zenithal Projection by Balance of Errors. Now a circular boundary does not fit the Pacific satisfactorily. That Ocean may be said to extend from 70° N. to 60° S., that is, through 130° of latitude; whilst in longitude we should include 100° E. and 70° W., that is 190°, but we really want more than that, for we have to consider Ceylon and India. But, all the same, it would be interesting to see the resulting picture of the Pacific on each of these projections. If one takes the central point, in each case, as being on the Equator, at 170° W., and the radius 90°, the map would include Singapore on the west and might just take in Panama on the east; it would just touch the Poles, though these are not really wanted. Airy's Projection by Balance of Errors is frequently mentioned, but rarely used. There is a recent example in *The Geographical Journal* for December 1938; Mr. H. J. Andrews gives us a map with a radius of 121½° which includes practically all the British Dominions; for the Pacific, however, a smaller radius would suffice.

There are thus many projections which might be used for the map of the Pacific, not all equally valuable, but all of interest. Whichever may be chosen, the map will be of greater service if it has printed on it certain great circle courses and distances.

Mr. A. J. DILLOWAY: *Summary presented in his absence by the Secretary.*

Mr. Dilloway considers the Pacific as a region trending generally north-west to south-east, covering some 215° of longitude, and with its strategic and geographical centre roughly in 20° N., 160° (W. Honolulu). What projection can show the relations of this vast area to the rest of the world? He has been considering the problem of thinking in terms of great circles, and recently published a paper in the *Journal of the Royal Aeronautical Society* (46 (1942), 4–31), "Cartographic solution of great circle problems." He considers that the requirements point away from the various minimum error and compromise projections and emphasize the importance of orthomorphism, of the zenithal class, and of projections which preserve a given relation over the entire area of the map.

A one-sheet map of the Pacific (and by this he means a general map with, say, two small-scale auxiliary maps on the same sheet) should provide for accurate measurement of distance, bearing, and great circle track. Areas should be comparable and shapes reasonably preserved. He proposes for the general map either a Mollweide, or preferably Eckert's Fourth Projection with polar parallel half the length of the equator, considering this the pick of

the conventional equal-area class. Mr. Dilloway would supplement this with a small-scale zenithal equidistant centred on Honolulu, the focal point for trans-Pacific routes. This could include London without extreme distortion, but the map is valueless beyond a radius of 120°. For portraying accurate world relations from unfamiliar viewpoints, he believes that this projection has no rival. It should have radial and circumferential scales for the measurement of distance and direction. A few very small circular hemispheres of this kind, constructed for important coastal centres and correctly sited on convenient blank spaces of the general map (or even on a Mercator) might prove illuminating and helpful.

Another of the auxiliary maps should be conformal. The National Geographic Society's recent Mercator map of the Pacific has a lengthy tabulation of distances. It might well have a transparency of a transverse Mercator projection for tracing great circle courses. An oblique cylindrical projection he considers out of the question, and he prefers for the orthomorphic map a stereographic projection centred on 160° W. with a close graticule-interval, bounded by meridians 100° on each side, and by straight lines perpendicular to the central meridian in latitude 75°. "It is fortunate for the preservation of shapes that no important land masses occur within about 50° of the centre." Mr. Dilloway would include a transparency on tracing-paper or in the form of a protractor, one-half of a closely-spaced stereographic equatorial projection in which the parallels are replaced by curves giving great-circle distances in statute miles, and would use a transparent scale equally graduated at either extremity to lay down tangents to circular arcs.

Further, and as a separate proposal for dealing with world problems, Mr. Dilloway suggests two polar hemispheres on the stereographic, mounted and geared together in such a way that they may be revolved to bring any two points onto a continuous great circle, not a meridian, passing through the point of contact. If each hemisphere is fitted with transparencies of halves of equatorial hemispheres, with the parallels replaced by curves giving distances in statute miles, as before, great circles can be passed through any desired points on the two maps, and the distance and course between any two places in the same hemisphere are determined at once. If the points are on opposite sides of the equator, it is necessary to turn the geared projections and adjust the transparencies so as to bring the traces of the same great circle into contact at the point of tangency. The distance is given by the sum of two intercepts. If the hemispheres are oblique and are centred on London, the value of the device is greatly increased.

Finally, for studying dispersal throughout the world from a given centre, Mr. Dilloway suggests an oblique cylindrical equidistant projection constructed on the great circle of which the proposed centre is the pole, so that the centre is represented by one edge of the map. This allows the introduction of a time dimension in the form of a graph plotted against axes of time and distance. By suitably adjusting the distance-scale of normal longitude, a surprisingly good map is obtained.

Captain G. T. McCaw: We are indebted to Sir Charles Arden-Close for an excellent résumé of the projections which are possible for the Pacific Ocean.

His suggestion that the lines showing the distances between two points should be drawn as great circles seems to me to be thoroughly practical for an ocean. On the general question of a projection for the Pacific one would imagine that the natural form would be some zenithal or azimuthal projection, well adapted to areas more or less circular, as the general shape of the Pacific Ocean is, unlike any of the other oceans. Therefore I think that for an all-round representation of that area we should use the zenithal projection: equal-area or orthomorphic according to the purpose for which the map is primarily intended. For special purposes, for sailing on the compass, one must have, and always will have, the Mercator.

The projection to which Sir Charles referred as a modified *Plate Carrée* seems to be also advantageous, but it is difficult to say how far it fulfils all the conditions of a general purpose projection. But there is no such thing as perfection in these matters; and I am not sure that a two point equidistant zenithal projection, with tangent points placed equatorially near Asia and America, would not offer the best compromise.

I thank you, Mr. President, for giving me an opportunity to take part in the discussion, and Sir Charles Arden-Close for opening up the question so thoroughly.

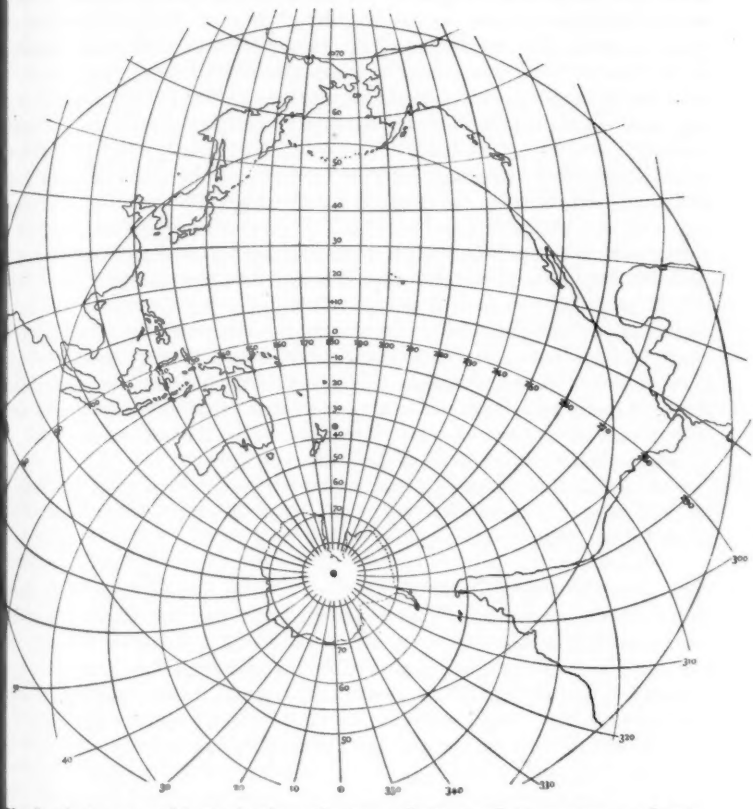
The PRESIDENT: Thank you, Captain McCaw, for a useful and helpful contribution to the discussion. I now call upon the Secretary, Mr. Hinks, who has some observations to make.

Mr. HINKS: Referring first to Mr. Dilloway's interesting proposals, I think he over-estimates the advantage of an equal-area projection and that his general map should show distances better than Mollweide or Eckert's Fourth can do. His proposed zenithal equidistant would give distances and bearings correct from the centre but from no other point. The normal Mercator used with a transverse graticule is good enough; but I do not consider that oblique cylindricals are out of the question. On the contrary, a set of two or three, or even the single C* (pole 35½° N., 292° E.), reproduced in the *Journal* for June 1941, allows one to trace great circles and measure distances and bearings over the Pacific area with great facility. But I do not find a transparency so good as a separate transverse graticule used with a piece of tracing-paper for each separate problem. His polar stereographic hemispheres geared together would perhaps be a little complicated, and the advantage that the trans-polar routes offer no difficulty is gained equally by the oblique Mercators.

I would call attention to Professor Rosen's Pacific map in the Swedish World Atlas, based on the idea of Aitoff. He begins by reducing differences of longitude by one-eighth, calculating a zenithal equal-area projection in which the meridian calculated for 70° from the centre is labelled as 80°, for 78°·75 is labelled 90°, and so on. He then reduces the vertical scale also by one-eighth. This gives a zenithal equal-area projection in which the scale is not quite the same along the equator and the central meridian, presumably because the one-eighth reduction has been applied first to the differences of longitude, before the calculation, and secondly to the vertical coordinates after the calculation. It suffers from the same defect as all the zenithals of the

ind, that the radial compression increases rapidly. Perhaps one may say of ny equal-area projection that no one can estimate the area of an irregular hape, and that to preserve equality of area by distorting shape is not of much ccount. Does anyone ever measure areas on atlas sheets with a planimeter? do not think so.

One of the oblique Mercators which was made specially to illustrate



Sketch of stereographic projection. Centre 35° S., 182° E., radius 110°, the outer circle enclosing a hemisphere

Captain G. S. Andrews' recent paper showed that three places, Panama, Bering Strait, and Ceylon, were at about equal distances above the central axis, and that a zenithal projection to include them should have a radius of 110° and centre in about 35° S., 182° E. And having in mind Mr. H. J. Andrews' excellent Round-the-World Map published in the *Journal* for December 1938, I have for some time been considering Airy's projection as corrected by Clarke and am constructing a map of the Pacific area upon it. It

has the interesting mathematical peculiarity that when constructed for a be bounded by radii α and β, the radial scale on these selected boundaries i unity; and if one makes α zero, that is, the zenithal case which is the only on ever used, the scale at the centre is unity. But the centre is a singular poin and at an infinitesimal distance from the centre the scale is less. If on chooses β as 100°, the radial scale close to the centre is 0·81; it increases a first slowly and then more rapidly, but at 110° is only 1·12, whereas the radia scale of the stereographic at this angular distance is about two-and-a-hal times as great. This makes one think that for a map showing the countrie bordering the Pacific, there may be some advantage in using Airy-Clarke. I have not been able to complete the calculations in time for the meeting, an can show only a sketch of a stereographic projection on that centre mad yesterday, and with the outlines inserted during the night by Mr. Denn while he was on fire-guard. This shows the areas to be included. The Air projection will diminish the outward radial exaggeration, making it averag unity in the zone between 90° and 110°. The result may be something like a mean between the stereographic and the zenithal equal-area. I hope we ma find that distances are not so badly represented on the average. In zenithal projections all the diameters and the circle 90° from the centre are grea circles, and by judicious choice of the centre one can do much. In the presen example, for instance, the great circles from Sydney to Panama and from Cap Horn to Tokyo are approximately diameters, and the 90° circle reproduces the great circle up the western coasts of the Americas, through the Aleutians, and down the eastern coast of Asia, shown as a straight line in the Oblique Mercator sketch-map on p. 18 of the *Journal* for July.

I had not thought of trying Clarke's minimum error perspective projection, but will include it in my experiment and am grateful to Sir Charles Arden-Close for the suggestion.

Sir CHARLES ARDEN-CLOSE: I think we have all learned something from this discussion. I was much interested to know that the metre being the ten-thousandth of the Earth's quadrant has actually been found useful for once; and that one can use fire-watchers for map-drawing. Anyway, quite seriously, I have listened to the remarks by Captain McCaw and Mr. Hinks with great interest. It is obvious that we have a very wide choice of projections; but the idea that we can get a projection that will suit everybody is fallacious.

The PRESIDENT: Heaven forbid that I should try to summarize this extremely technical discussion to which we have listened. I am sure that you have all heard it with as much interest as I have and that you will agree that we have, many of us, learned a great deal we did not know before we came here this afternoon. We thank Sir Charles Arden-Close and those who have followed him for their contributions to the discussion and for all they have told us so clearly, so concisely, and so briefly.

There are on view certain atlas maps of the Pacific which Fellows might like now to examine; they are well worth study.

THE TIBU PEOPLES AND THE LIBYAN DESERT

MAJOR R. F. PEEL, R.E.

MODERN exploration of the Libyan Desert has revealed it as one of the most scantily peopled regions of its size on the face of the earth. Until twenty years ago, when penetration into the interior first started, it was frequently assumed that the whole area south and west of the Egyptian and Libyan oases was completely uninhabited, and had remained so since man first appeared. Exploration has to a great extent confirmed the first part of this view; but the prolific archaeological remains found by each successive expedition have shown clearly that until the neolithic period, at least, conditions were very different. Unfortunately investigation of this subject had only just begun before the outbreak of the present war, and attention had, not unnaturally, centred almost exclusively around the ancient relics. The history of man in the area since the great exodus which appears to have taken place about 2500 B.C.[1] remains virtually a closed book; and many authorities, impressed by the present desolation, have given the impression that it dates back right to the end of the neolithic period. There are many indications however that this view is far from correct; for although living men were found in the interior at only a few small and scattered oases, most expeditions found traces of modern native occupation scattered over a fairly wide area, and such historical references as bear upon the question speak quite clearly of numerous and active dwellers in the desert. Herodotus, the earliest reliable source, devotes much space to Libya, and tells of various different peoples inhabiting it, the most interesting being the Garamantes and the Troglodytes; the former apparently a fairly civilized people living somewhere in the Fezzan area, the latter a very primitive and mysterious group of the interior. Leo Africanus, among Arab authors, speaks of the Bardoa as a division of the Berber peoples inhabiting the interior of Libya. Some authorities have identified Bardoa with Bardai, the oasis in northern Tibesti, but this seems rather doubtful. Edrisi however mentions the Soghaua, who can be quite clearly identified with the modern Zaghawa of Darfur and Kordofan; while Imam Ahmed, historian to the Sultan Alaoma of Bornu in the sixteenth century, first mentions the Tubu; probably the Teda (Tibu) of Tibesti. All these historical references are vague, but they do indicate the presence of native peoples in the far interior of the deserts; while the histories and legends of the settled lands round about tell us something of their nature and habits. This is particularly true of Egypt.

Throughout Egyptian history there runs a consistent thread of raiding and invasion by fierce and mysterious peoples from the western deserts. Leo Africanus for example relates that the King of Nubia "maintaineth continuall warre against the people of Goran (who . . . inhabit the desert and speak a kind of language no other nation understandeth)." MacMichael, among others, identifies the region of Goran with the southern Libyan Desert: "Throughout history the nomads of the west, Libyans or Berbers, have maintained an intimate connection with the Nile valley . . ." and again, "The Bayuda Desert, as late as the seventeenth century, was still known, as

it was to Leo Africanus, as the Desert of Goran, Gorhan or Gorham . . . a name connected with Kora'an, and, as I believe, with Garama and the Garamantes." [2] Henderson however summarizes the matter in the words "In the days of Herodotus, and ever since, the Garamantes, Guraan, or Teda, a dark but essentially Hamitic race, centred on Tibesti and nomadic by nature, have preserved an unbroken control over the western Bayuda Desert up to within 100 miles of the river." [3]

This picture is borne out by the legends collected by modern explorers. Born of the recollection of these raids, the settled cultivators of Egypt produced many wonderful stories of inhabited valleys and oases in the desert wastes, and even of walled towns. They recounted how the inhabitants of these desert strongholds, generally described as Blacks, quite frequently raided the outlying Egyptian oases, vanishing swiftly back into the desert to defy pursuit. From such material arose the legend of Zerzura, a subject frequently discussed in former pages of this *Journal*. To locate this tantalizing place formed one of the principal initial incentives to exploration; and although Zerzura itself has probably not been found (unless one accepts Almàsy's claim to the title for his three wadis in the northern Gilf Kebir), exploration did find many hitherto unknown oases. The whole subject of Zerzura has been ably discussed by Almàsy, and the legends of raids on the Egyptian oases are fully presented in his book.[5] Although disappointed in finding Zerzura itself, modern explorers did discover J. 'Uweinat, J. Archenu, Merga, Bir Bidi, and the Gilf Kebir; while Kufra and its neighbouring oases were more completely explored. At all these places traces of modern occupation were observed. Kufra and Tazerbo were occupied by Arabs, who had captured these oases in the nineteenth century from the indigenous Tibu, but many of the Tibu remained. A small party of Tibu were discovered at 'Uweinat and Archenu by Hassanein Bey in 1920 and 1923, under a chief Herri; and although their occupation did not persist beyond 1933, it is clear from their statements that the Tibu had known the mountain oasis for centuries and visited it regularly both to graze camels, and as a *pied-à-terre* for raids.[6] At Merga, Newbold and Shaw in 1927 found recently built grass and reed huts, although the oasis was deserted. They learned however that it was well known to the Bideyat and Guraan people of the south (groups related to the Tibu), and visited by them regularly.[7] Similar remains were found by Almàsy at Bir Bidi nearby in 1935,[8] who also found many traces of recent Tibu occupation in the wadis of the northern Gilf Kebir which led him to claim their identity with Zerzura. Again, in conversations with Tibu, Almàsy was told quite definitely that all these places were age-old Tibu strongholds, the Tibu having known and traversed the whole of the desert long before the appearance of the Arabs.[5]

This very brief review of some of the more salient historical evidence gives a very different impression of the human history of the Libyan Desert from that commonly put forward; and it was with a view to investigating this subject that the writer collected all traces of recent native occupation that were seen when visiting the Gilf Kebir–'Uweinat area with Major (now Lieut.-Colonel) R. A. Bagnold in 1938.[1] The material so collected was being studied before the war in relation to the abundant archaeological materi

Phot. R. A. Bagnold

Guraan reed huts at Merga Oasis

Ruin of grass and matting hut, 'Uweinat

Guraan storehouse, 'Uweinat waterskins and camel gear, found inside, lying doorway

Phot. O. H

Small hut of stones and mud, 'Uweinat

le, lying

hot. O. B

lected by O. H. Myers on the same expedition; but the completion and blication of that work has naturally been postponed.[9] The present paper ms merely a preliminary note on the subject, and its conclusions are only tative. Material was collected mainly in Karkurs Talh and Murr at weinat, and in Wadi Abd el Malik at the Gilf Kebir, but for convenience l be described by categories rather than by localities.

The terms Tibu and Guraan (Goraan, Gorane) are used with a variety of anings in literature on Libya, and some confusion is unavoidable. In the t, Tibu is used in the main as a comprehensive term to include all the ples discussed; Guraan as a general term for the southern tribes. This ows established custom in a matter where clear definition has never been empted. Other names refer to specific tribes, as explained later.

Note.—Owing to paper restrictions it has been necessary to omit the first part his paper, comprising a summary of the historical evidence, and of references ative peoples in the records of modern expeditions to the Libyan Desert. This been placed in the Library for the use of students.

bitations

n K. Talh, 'Uweinat, were found the ruins of two or three small grass and ting huts, roughly square, supported on a framework of acacia branches. gments of a similar hut were noted in Abd el Malik in the north. These s were very similar to those found by Bagnold at Merga, and to those cribed from Tibesti, Ouadaï, and Ennedi by Tilho,[10], and others [11], [12], [13]. An illustration in a short paper by Ballif shows a very similar hut n Tibesti.[14]

lore common however were stone shelters. Some of these, at 'Uweinat, e circular, well-built affairs, about 8 feet in diameter, with a small gap door but no trace of roof. They were generally built on ledges above the i floors. More common were shelter walls built around natural hollows he wadi walls. One of these, in Karkur Talh, had the interstices of the es packed with mud to keep out the wind. Another was found in K. Talh a ledge about 10 feet above the wadi floor; only some 4 feet across by t 6 inches high, square, roofed over, and with a small opening for door, as probably a storehouse for food. Inside were goatskin water-bags and s of camel-saddles. Natural clefts in the rocks had evidently been used helters of an even cruder sort, traces of fires, bones, and other refuse being d in many, with occasionally branches stuck into the rocks to form pegs anging up water-vessels and food.

the literature on the Tibu peoples there is frequent mention of stone ters and cave habitations. The mysterious Troglodytes of Herodotus e to mind immediately. At Tibesti Tilho records finding "Troglodyte ges" in the crater of Emi Koussi, and several hundred mountain Kous- "living miserably in caves." [10] Ballif speaks of stone huts at Tibesti,[14] Réquin,[15] and Noel,[11] speak specifically of round stone huts, according e latter "built on rock terraces, of a circular wall of dry stones with a of branches." Rottier also describes rectangular stone huts at Tibesti, none of this type were seen at 'Uweinat. The name *Ti-bu*, *Te-bu*, or

Tu-bu means simply rock-people,[16] and is given to the inhabitants of Tibe by the Arabs of the north, though whether because of their rocky mount homeland of Tibesti, or of their stone dwellings, is not decided.

Stone circles have been found in many parts of the Libyan Desert, and ha generally been considered to be extremely old. Many no doubt are, but 'Uweinat many smaller ones among the Tibu settlements, although impossi to date, seemed to be fairly recent. The purpose of these stone circles always difficult to interpret. Some smaller ones had traces of firing, and m have been simply hearths. Others, with stones in the middle, may have be rests for water-bags, but the purpose of the larger ones, often 20 feet and mo in diameter, and built of a single ring of flat stones, is difficult to sugge Réquin mentions large stone circles associated with the ruins of round sto huts at Tibesti,[15] but does not give any details. It is possible that some we the foundations of walls. On an isolated hill at the north-east corner of t Gilf Kebir, the writer noted a low circular wall of stones suggesting a look post, and some stone circles may originally have formed part of similar co structions; but the complete absence of other stones than the base ring many examples is rather a puzzle.

Graves

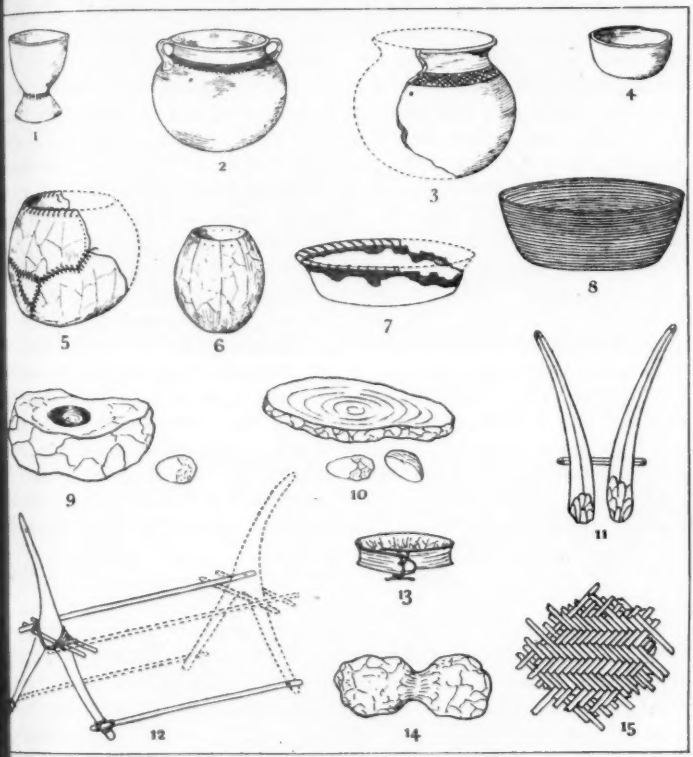
A fairly recent grave was found in the upper part of Karkur Talh, 'Uweina The tumulus was surrounded by a ring of upright stones (quite different fro the ordinary stone circle, which is of flat stones), and two isolated point stones inside the ring prolonged the axis of the grave in a line almost exact north–south. On top of the mound lay an earthenware cup, damaged but n deliberately broken. As the grave was not opened, it is not known whet any objects were buried with the body. Information on Tibu burials scanty, but Noel has noted the north–south alignment at Tibesti,[11] wh MacMichael records the same custom from the Zaghawa of northern Dar where the ring of stones is also built round the grave.[17]

Material objects

Apart from the plentiful neolithic sherds, more modern pots and sher were found at both 'Uweinat and the Gilf Kebir. There were eight or t more or less complete large round pots, and some smaller ones. All we similar; hand-made by modelling, coarse, and rather porous, with a lar admixture of sand and micaceous particles, and fragments of limestone a bone. Most were blackened by fire and coated with soot. The only decor tion was a rough cross-hatching, scored before firing. The cup found on t grave was distinctive, of finer and more delicate construction, and with impressed line of decoration. I have been unable to find samples of Ti pottery in British museums for comparison, but as the nomadic Arabs do n make pottery,[18] there can be little doubt that these pots are of Tibu origi Rough pottery is made by both the Tibu of Tibesti, [15], [12], and the Guraan a Bideyat of Ouadaï and Ennedi.[18]

Some half a dozen baskets of various types were found, in both plaited a coiled techniques. Most of the latter were shallow, round, basin-like vessel the former limp bags very similar to the *maktaf* of the Egyptian fellahin. So had leather handles. One of the basin-type baskets was carefully coated wi

ay, and had the rim bound with leather thongs; possibly it was used for olding liquids, and an interesting parallel with one theory of the origin of ottery is suggested. Fragments of matting, of plaited palm fibre, ropes of isted palm leaf strands, and a basket net of knotted palm-rope were llected around some of the habitations. Two unusual vessels were found, ade of large round and thin gourds. These were somewhat fragile, and had



Cup found on grave; 2, 3. Cooking pots; 4. Small earthenware bowl; 6. Gourd vessels; 7. Coiled basket coated with clay; 8. Coiled basket; Basalt quern with small grindstone; 10. Sandstone quern with two small ndstones; 11. Part of camel saddlery; 12. Tibu camel saddle, forked branches d slats bound together with hide thongs; 13. Bark ring; 14. Waisted stone; . Weave of plaited baskets and mats

e rim carefully bound with leather thongs, and cracks sewn up in a similar nner. There were also water-skins, of goat-skin with the hair still on. In e works quoted for Tibesti and Ouadaï, frequent mention is made of ketry and matting, but precise details are not given. Lavit however has blished a photograph of matting from the Chad area which is exactly like e 'Uweinat examples.[19]

Querns and grinders of great age are common in the Libyan Desert, bo
'Uweinat many were found actually in and around the Tibu camps, and
undoubtedly been used by the Guraan. Bagnold has told of Herri's p
using them to grind up coloccynth seeds,[20] and many traces of colocc
and other wild seeds were found by the writer around the querns at the T
camps. An improvized grater made from part of a petrol tin provide
startling contrast. Many authorities, from Nachtigal onwards, have n
the use of coloccynth and other wild seeds by the Tibu peoples in hard ti
Hassanein found Herri's party eating coloccynth at 'Uweinat in 1923, T
noted it among the Bideyat of Ennedi, as also did Slatin much earlier,[21] w
Ballif, at Tibesti in 1921, mentions a paste composed of ground-up bo
date stones, coloccynth seeds, and doum nuts as a common dish.[14] The s
are first soaked to get rid of the bitter taste. The use of querns is interes
Noel has noted it from Tibesti.[11] At 'Uweinat many apparently used by
Guraan were identical with the neolithic types, and had probably b
picked up and utilized; but others, much cruder, were modern.

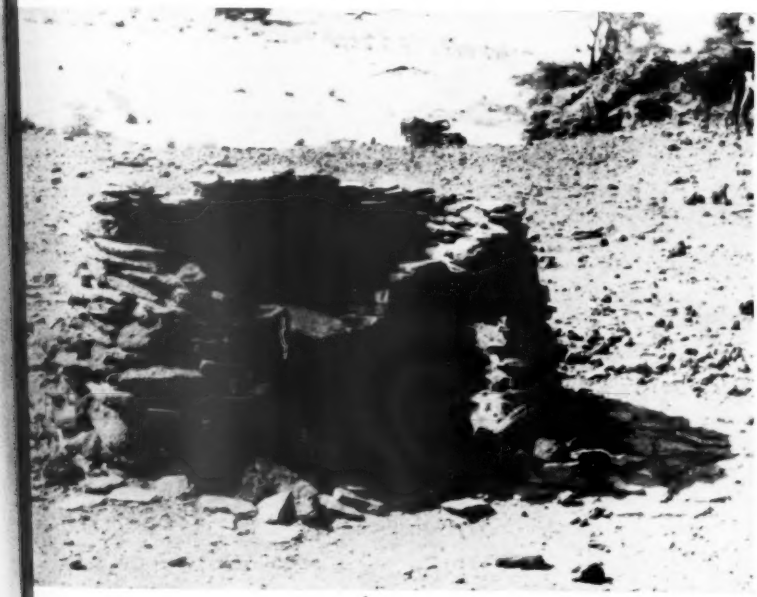
A few miscellaneous objects were found. Parts of camel-saddles w
picked up at both 'Uweinat and the Gilf Kebir. They were simple c
structions, made of forked branches with longitudinal connecting rods bo
on with leather thongs. The descriptions given by Rottier [13] and Bouillez [12]
Tibesti and Ouadaï agree exactly. Camel dung and bones were noted at b
localities, and many camel tracks. A waisted stone of hour-glass shape
found in Abd el Malik, of unknown purpose, but perhaps some part of c
gear. Red glass beads were found at 'Uweinat, and fragments of blue cl
Many authors have commented on the distinctive blue garments of the T
Finally, there was a peculiar ring of bark in Abd el Malik, tied up with p
fibre; it may perhaps have been part of a ring trap such as Winkler descr
from the deserts east of the Nile.[22]

Rock-drawings

Rock-drawings and paintings have been found at many places in
Libyan Desert, as elsewhere in North Africa, and much has been wr
about them. 'Uweinat is a main centre, and in 1938 H. A. Winkler dev
much time to a detailed examination of many sites.[23, 24] As with other hu
material in the desert, attention has been concentrated almost exclusivel
the ancient examples, and more modern works have been neglected; but
exist in fair quantity and are well worthy of the ethnologists' attention
'Uweinat, while Winkler was studying the ancient sites, the author exam
the modern. As with all such material, dating is extremely difficult, bu
drawings are all obviously recent. There is practically no patination,
drawings standing out clear and white on the rocks as though done yeste
and the subject is generally the camel, which does not appear at all i
ancient examples.

The recent drawings examined were all similar in form and techn
somewhat crude and angular, and done by simple pecking. No pa
examples were discovered. Camels and men were the subjects in all. O
some ten or a dozen sites studied, however, it seemed that two different g
were represented; the one quite recent, the other somewhat older. The

Tibu grave with circle of upright stones and two pointers, K. Talh



Round stone shelter, 'Uweinat

Recent Tibu rock drawings, both older and younger groups represented, K. Talh

Human figures of younger group, K. Talh

lightly greater degree of patination of the latter group, and a difference in tyle. The older examples consisted exclusively of animal drawings, all pro-ably camels. They are crude, stiff, and ungainly, some figures being drawn lmost in straight lines. The body of the camel is only outlined, and the istinctive features are by no means clear.

The figures of the second group, believed to be more recent, show both amels and men. The camels, although somewhat ungainly, are much more ealistic than the earlier ones, as the single hump, the rounded belly, the lean oins and flanks, thin legs with knobbly knees, and even the pendulous lower ip are clearly emphasized. Rounded outlines have replaced crude lines and he whole body is pecked out uniformly. Several groups and occasionally ingle human figures found with the camels seem to belong to the same period. ll are very similar, simple blocked-out silhouettes with no distinctive features f clothing or anatomy, save that in some cases the legs are thick and long, iving rather the appearance of woolly trousers. All have the arms raised and ent; and in many cases the normal two joints have been added to, in extreme ases to the extent of four elbows and five separate limbs to the arms, which ecome extended zigzag lines. The men may be holding some bent objects t arms' length, for in one isolated figure with arms of three sections the third ight easily represent knives or similar implements; but more probably it is rtistic exaggeration. All figures in this group, men and camels, are remark-bly fresh, and the style uniform; quite possibly one group, or even one rtist, drew them all. The authorship of these recent rock-drawings cannot be ettled with certainty, but the general circumstances appear to rule out any ut the Guraan-Tibu groups who seem to have known and visited 'Uweinat r a very long time. The Arabs did not know 'Uweinat at all until quite ecently, and did not visit it. The drawings also are quite different from the ual tribal *wasms* of the nomadic Arab. Tilho mentions seeing drawings f horses, dogs, and camels at Tibesti, together with ostrich and hippo-otamus,[10] but gives no details. Probably the sites he saw contained a super-osition of drawings of very different ages. Authier again mentions drawings f camels in Borkou, and the illustrations he gives show some similarity to e 'Uweinat examples.[25] F. de Chasseloup Laubat also, in his monograph n the drawings and paintings of the Ahaggar area, mentions that in addition ancient types, he found series of "naive and crude drawings representing en on camels, dogs, etc. . . . with very fresh patina." He classes these as ibico-Berber and states that examples abound in the Central Sahara, but at they have "no artistic, and little historical interest." He also found some intings of men on camels, done in blue, which he groups in the same tegory, assigning a Tuareg origin to them.[26] Laubat's illustrations include e of these recent drawings. The style appears to be generally similar to at of the 'Uweinat examples, although most of the subjects are men on mels. An interesting feature is that one unmounted human figure stands exactly the same posture as that typical at 'Uweinat, with the arms raised d bent, but no zigzag extensions.

There is thus plenty of evidence for modern pictures in the Tibu country, hough details are lacking for comparison; and it is known that the modern uraan do draw on the rocks, especially when inspired by ancient pictures.

In the absence of contrary evidence therefore it seems reasonable to ascribe the modern 'Uweinat drawings to the Guraan and Tibu who used to frequent the mountain. They might have been drawn any time from two or three to several hundreds of years ago. Possibly Herri's little band were responsible for the more recent. In any case they must be considerably younger than those described by Winkler, if only from the presence of the domesticated camel, which many archaeologists believe was introduced into the Libyan Desert not earlier than the sixth century and probably about the third century B.C.,[27] and Breuil, in his classification of the paintings at In Ezzan, dates his Phase 9, the Libico-Berber Phase, as commencing about that time.[28]

It has seemed worth while to describe the material collected in some detail, for to the writer's knowledge no similar collection has been recorded from this region. Even without elaborate analysis it is clear that all the objects can be readily paralleled among both the Tibu of Tibesti, and the Guraan and Bideyat of the south, while they are quite alien to the Arabs; and the ethnological evidence thus confirms the historical material: first, that the Tibu peoples alone can be described as the true natives of the Libyan Desert; and secondly that until quite recent years they roamed over a much wider area than that in which they are now to be found. Kufra and Tazerbo were their strongholds for centuries before the Arabs managed to reach and conquer them. They certainly knew, visited, and periodically occupied 'Uweinat, Archenu, and the valleys of the Gilf Kebir; they alone knew and used Merga, Bir Bidi, and other small and remote oases; their water jars were found at Abu Ballas (by John Ball) on the road to Dakhla; indeed it can be said that their realm extended across the whole of the Libyan Desert as far as the Cyrenaican and Egyptian oases, the Arba'in road, and even at times the Nile Valley. All the historical evidence seems to identify them directly with the mysterious "desert blacks," who periodically raided Siwa, Dakhla, and the other Egyptian oases, and with the "desert Goran" written of by Leo Africanus in the sixteenth century, who terrorized the Nile valley peoples and on whom the King of Nubia "waged continuall warre."

The exploits of Gongoi, a Guraan chief, and his band in the early 1930's may be viewed as the last flaring up of a record of wandering and raiding that had troubled the settled peoples around the desert for centuries; perhaps from the dawn of history. The general outlines of the story seem clear, for the evidence, though scanty, hangs well together; but the details, in a land almost without written records, are probably lost for ever. The wanderings of the Tibu were being curtailed even before Europeans penetrated into this vast arid land, and when they did, they found the former Tibu strongholds for the most part deserted, and the bulk of the Libyan Desert in a state of emptiness it may not have experienced for hundreds or even thousands of years.

What these Tibu and Guraan were like, and how they managed to exist in this land now so barren and waterless, and to cross hundreds of miles of waterless desert to raid the Nile valley and the Egyptian oases can be answered only by comparison with the surviving groups of the Tibu peoples to the south and south-west.

The Tibu

The Tibu peoples, because of the remoteness of their homelands, remained until recently among the least-known of African peoples. During the last twenty years a fair amount has been written about them by French, and more recently by Italian, authorities, in whose territories most of the remaining groups reside, but there is little in English. Almost all information is recent, and only begins at a time when the traditional Tibu culture had begun to break down.

As with all human groups, it is difficult to define exactly the limits of the Tibu. Criteria of physical appearance, language, and cultural factors seldom coincide, and information on all aspects is somewhat imperfect and uneven. Taking a composite view however their constitution and range may be summarized as follows. The central core is certainly to be recognized in the Tibu of Tibesti, more correctly named Teda. Even here however there is a large subject group of *kamadja*, representing the descendants of former captives and slaves. Outwards from Tibesti, elements of Tibu spread northwards into Fezzan, and west to the borders of the Tuareg country. The oases of Kawar are peopled partly by Tibu, partly by related Kanuri from the south. South-west of Tibesti, groups closely related to the Teda (but distinguished by them as Dazza), spread over the lands down towards Chad: Bodele, Kanembu, Kreda, Kecherda, and other Guraan peoples. The numerous Kanuri of the Chad area show strong affinities of physical appearance and language, though they have adopted agriculture and a distinct mode of life.[13] To the east, Tibu and Guraan (the common Arabic name for the southern Tibu) tribes wander over the Bahr-el-Ghazal area, Borkou, and the whole of northern Ouadaï. Here there are many different tribes: the Ounias of Ounianga, the Nakazza, the Mourdia of the Mourdi depression, the Gaeda, and others. The plateaux of Erdi and Ennedi, stretching far into the desert zone, are purely Tibu, the Bideyat being one of the chief groups. Farther east the great Zaghawa tribe, and possibly some others like the Meidobi, are closely related.[29]

North and east of Tibesti the desert plains are now almost entirely uninhabited, but the Kufra and Tazerbo oases, although to-day they have a large Arab population, were originally purely Tibu, and were probably colonized from Tibesti.[30] Hassanein Bey noted the former existence of Guraan, both from Kufra, and from the south, at 'Uweinat, and elements of Tibu have even been detected in the Cyrenaican and Egyptian oases; probably the descendants of raiding groups. The total numbers however are small and seem to have declined greatly during the last hundred years. Thus at Tibesti Nachtigal, in 1870, estimated the population at twelve thousand; Le Coeur, in a recent paper, gives only six thousand.[31] Probably not more than a few hundred thousand, at most, still exist, even including the mixed groups to the south. Rottier has noted that the birth-rate at Tibesti is low,[32] and that few Tibu live beyond middle age.

Racial material on the Tibu is mainly confined to the Tibesti area and Kufra. Earlier French, and more recent Italian, work has been ably summarized by Sabatini,[30] and without going into details it is clear that the Tibu are predominantly a Hamitic people. The build is tall, and excessively lean

and wiry; the head generally long (range of Cephalic Index for most groups is between 73 and 79), the features regular and well formed, with straight or hooked, and fairly narrow nose. Hair however is generally woolly and very dark; eyes dark brown, and skin a deep cinnamon brown. Probably this dark colouring, which sometimes approximates to the negro, gave rise to the common Arab description of blacks. Negroid features are quite common; broader nose, thickened lips, and other typical negroid features being seen even in the north, and becoming increasingly marked towards the south. Negroid features predominate in the southern groups, like the Bideyat and Zaghawa,[17] and south of them the Tibu groups grade into the mixed negroids of the Sudan and Congo watershed area. On the whole however it appears that the Tibu ring comprises an island of Hamitic peoples who have, owing to their isolation in the great deserts, remained largely immune to negro admixture from the south and later Arab pressure from the north. The physical relationships and evolution of the Tibu group have been little investigated, but it seems probable that they represent a fairly early element in the Hamitic invasions of Africa. It is interesting, and perhaps significant, that the many-pointed throwing-knife is indigenous to them, a fact which seems to link them with other Hamitic and half-Hamitic peoples to the south and east. A further possible connection has been traced by Arkell in the presence, among groups in Darfur, of "Mani" magic, which also appears among the Azande.[33] These points however, though interesting, lead beyond the limits of the present notes.

We have little knowledge of the early Tibu peoples; modern information pictures a declining culture, of which however the main elements are fairly clear. Life centred essentially round the camel and for all true Tibu groups was extremely mobile, with camel-breeding, the herding of sheep and goats, and always raiding, as the essential features. The whole culture was necessarily highly specialized to make life possible in this land the greater part of which is complete desert, where water and grazing exist only at small isolated points separated by great distances. In Tibesti, even to-day, the pastoral groups live in a state of continual movement over the mountain *tarso* pastures and between wadis and wells, and the same is true of the more open lands to the east. With such a life, the development of material culture is bound to be meagre, hence the typical Tibu settlements of scattered collections of grass and matting huts, quickly built and pulled down. In rocky country, and especially in winter, more solid rock-shelters and stone huts are used. A few pots and baskets, mats, waterskins, and leather bags, almost completed the furnishings, all objects being readily transportable by camel. Normal food included little meat, save an occasional goat or wild animal, milk and vegetables being the mainstays. Like all true pastors the Tibu seem to have despised agriculture, although subject groups at Tibesti cultivate small patches of millet and wheat, but they would collect dates at harvest time, and in lean seasons, wild seeds and anything else edible, even the few lizards and snakes, in particular the giant lizard *goubontounou*. In the south and south-west many of the semi-Tibu groups have settled down, started cultivation and the herding of cattle, and have adopted the circular palm-frond hut of the Sudan, and even mud-huts, but these traits are not indigenous.

The Tibu, obliged by the harshness of the environment, split up into small groups and spend much time in travel in search of new grazing. A rudimentary clan system has been described in Tibesti, with noble families, and a nominal chief,[15] but the general impression left with early observers was one of chaos; "an anarchic state" is how Loefler described it.[34] Apparently however small groups frequently banded together for the purpose of raiding. Islam came to the Chad area with the Arabs, and in modern times Senussi influence gradually permeated through the Tibu, but they have never had more than a veneer of Muhammadanism superimposed on ancient primitive beliefs and customs.

Raiding and pillaging seem to have been one of their mainstays, and raiding coloured the whole pattern of their life. The early French expeditions speedily put a stop to much of the wandering and despoiling, and their records are full of comments on this aspect of the Tibu. Legends collected by Carbou tell of continual movements, raids, and expeditions against the Tibu by the Sultans of Kanem, Bornu, and Ouadaï.[35] The Tibu seem to have harried and collected tribute from all travellers within their realms, and their activities were a sore trial to the early caravaners. Beyond that, they swept out of the deserts to raid the settled populations as far afield as Ouadaï and the Chad area, Cyrenaica, the Egyptian oases, the Nile valley, and Kordofan. Many of the raids seem to have been inspired by the need for fresh camels; others by the desire for slaves, food, and more miscellaneous plunder. "The name Erdi," says Tilho, "implies expedition, and seems to have been applied to that region from time immemorial because it served as a meeting-place for the bands of raiders who put the caravans to ransom and pushed their raids as far as Kordofan and northern Darfur, and sometimes even to the Nile valley itself in its middle reaches." These raids must frequently have carried the Tibu over enormous stretches of country, with gaps of hundreds of miles between water-holes, and all authorities are unanimous in their astonishment and admiration at their skill and hardihood. Bouilliez, to quote only one source, says: "They . . . are perfectly at home in the desert, and travel very quickly, guiding themselves by the sun by day, by moon and stars at night. They also recognize minute details to guide them to their objective, and are expert trackers. On the march they are indefatigable, and in urgent cases can travel 100 kilometres a day for several days. Their fortitude, strength, and stamina are tremendous. They can go twenty-four hours without water easily, and their physical resistance enables them to cover great distances on foot. A Kanem Teda, surprised at a well, tried to reach, on foot, the next well 150 km. away." [12] Ballif records that in a Teda raid on Air, in 1912, the party met disaster, and only one man escaped. He walked back to Tibesti (a distance of over 1000 km.), living on the flesh of one goat, and on water carried in its skin.[14] Many of their routes in regular use had stretches of four or five days between waters and grazing, and on raids they must frequently have performed feats of endurance almost without parallel in desert history.

The general temperament of the Tibu relates clearly to this long history of raiding. A people of individualists, they are reported as being ruthless but cautious, even appearing cowardly, cunning and deceitful, rapacious and

untrustworthy, fierce and suspicious. "If I had to seek in the animal kingdom for a term of comparison for these tribes, I think I should choose their fellow-denizen the jackal; they possess its cunning, its audacity, its cowardice, its mischievousness, its endurance, its speed, and its predatory instincts." Thus Tilho writes, after some weeks' experience of them. These qualities, admirable, even necessary, for the old life, do not help the Tibu to adapt himself to changing conditions, and, from the limited information available, it seems clear that with the restriction on wandering and raiding, the old culture has decayed, the population declined, and that the Tibu, like many another specialized primitive people, may well be on the way to extinction.

The brief sketch of Tibu life and culture given above pictures conditions as they were in the early years of this century. To-day, with the pressure of European pacification, free wandering and raiding have been almost eliminated, and most of the Tibu groups are in a state of decline, scraping a bare existence from what they can gather and catch. The reconstruction however reveals something of how they could have reached the Egyptian oases, for long a mystery to the local peoples; with wadis like Abd el Malik as "grazing bases," and perhaps dumps of water in jars to help them over the longest waterless stretches, they seem to have been able to overcome even the worst conditions that the desert could provide. For centuries they appear to have been the true desert people, at home in the vast solitudes which so terrify the Egyptian fellahin, and which deterred even the Arab Badawin. How far back this history stretches can only be a matter of conjecture; but supposing the conditions to have been the same, it can only have developed with the camel. The problem of the camel in north Africa is rather a difficult one. It is generally believed not to be indigenous, and most authorities hold that the domesticated camel was introduced, probably by the Persians, not earlier than the sixth century B.C. There is some evidence however, both archaeological and skeletal, that wild camels may have existed in north Africa long before this,[27 (a)], and in the present state of knowledge it would be rash to make dogmatic statements. If it is the case however that the domesticated camel only appeared a few centuries before Christ, the modern Tibu culture cannot have originated earlier. Who, and what, the Tibu were before this and whether they occupied their present realms in those ancient days, are unsolved problems; but the writer has a strong inclination towards identifying at least one element of them with the Troglodytes of Herodotus. Many authorities, including Keane[36] have assumed a relationship between them and the ancient Garamantes, largely because of the similarity in the names Garamantes and Guraan; but on many grounds this does not seem very probable. Our only source of early information, Herodotus pictures the Garamantes very differently from what we know of the Tibu. Although his locations are vague, he appears to place the Garamantes somewhere south-west of the Gulf of Sirte. They were "an exceeding great nation," and evidently fairly well civilized, for they had four-horsed chariots, oxen, and practised agriculture at palm-bearing oases. Further, they were not a warlike people, in spite of their chasing of the Troglodytes; "they have no weapons

war, and do not know how to defend themselves." [37] These facts accord ill with the Tibu; while the discovery of their ancient capital of Garama near Murzuch seems to locate them definitely in Fezzan, a conclusion supported by Sergi's demonstration of the similarity between ancient Garamantean crania and those of modern Fezzani Tuareg.[38] It seems much more likely that the Troglodytes, whom the Garamantes chased, who lived in caves and ate lizards and snakes, whose swiftness of foot astonished the old historian, and whose language sounded like the squeaking of bats (a remarkably accurate description of the Tibu tongue, according to many observers), were the earliest Tibu, and they may well have centred around the Tibesti area.[13] They can hardly have had the camel at this time, and probably they were a primitive gathering folk, tied to the mountain areas which afforded caves for shelter, some food, and water. Later, with the complex human movements which affected the Tibesti–Chad area, other stocks no doubt entered and blended with them,[13] and with the arrival of the camel their distinctive modern culture developed. It seems quite likely however that the cave-dwelling, eating of reptiles, and so on, which are still to be found among them, are direct survivals from the early Troglodyte groups, absorbed into the new culture unchanged.

All theories about the past history of the Tibu however are directly affected by the climatic factor, and in spite of its complexity a few words must be added on this problem. It is abundantly clear, from archaeological and geological evidence, that the Sahara and Libyan Desert experienced long pluvial periods in prehistoric times, probably related to the ice-ages in Europe, and that, up to neolithic times, the area had sufficient water and vegetation to support abundant fauna and a considerable population of nomadic cattle-pastors. Myers, on archaeological grounds, has postulated a great drying-up of the Sahara, culminating about 2500 B.C. with the exodus of the prehistoric inhabitants.[9] There are various lines of evidence however to suggest that the climate has not been uniformly arid since that period. Legends collected by Réquin from the Tibesti Teda distinguished three periods in their history. The first, "of which they have no recollection," was a period of abundant rains, extensive pasturage, and numerous population. To this period Réquin assigns the prehistoric rock-drawings of cattle, elephant, and ostrich, stone axes and querns, and other archaeological material. The second period, of indefinite age, was marked by increasing aridity, and the exodus of much of the population (this would perhaps correspond to Myers' "drying up"); but a third period was distinguished, the modern, with the modern occupation, under less arid conditions.[15] Hassanein formed the impression in 1923 that the country was much drier than usual, and each subsequent explorer seems to have been more impressed by the aridity, no modern party having experienced a heavy downpour such as Kemal el Din recorded from 'Uweinat in the early 1920's. Quite possibly, as many authorities have argued, the Sahara has been getting increasingly dry even during the historical period,[39] but more likely there have been fluctuating periods of greater and lesser aridity, the present being certainly one of the former. To such factors the history of the Tibu must be intimately related, but this problem, like that of the possible relationships of the Tibu and other modern peoples to the

prehistoric inhabitants, must await years of detailed field investigation for resolution.

In the paper place-names are given in the local official form and names of tribes according to established custom.

REFERENCES

(1) Bagnold, R. A., Myers, O. H., Peel, R. F., and Winkler, H. A. "An expedition to the Gilf Kebir and 'Uweinat." *Geogr. J.* 93 (1939) 281–313.
(2) MacMichael, H. A. 'History of the Arabs in the Sudan.'
(3) Henderson, K. D. "Nubian Origins." *Sudan Notes* 14 (1931).
(4) Bagnold, R. A. "The last of the Zerzura legend." *Geogr. J.* 89 (1937) 265–268.
(5) Almàsy, L. E. de. "Récentes explorations dans le Désert Libyque." *Publ. Soc. Roy. Géogr. d'Egypte.* Cairo, 1936.
(6) Hassanein Bey. "Through Kufra to Darfur." *Geogr. J.* 44 (1924). 'The lost oases.' London, 1925
(7) Newbold, D., and Shaw, W. B. K. "An exploration of the southern Libyan Desert." *Sudan Notes* 9 (1928).
(8) Almàsy, L. E. de. "Bir Bidi." *Sudan Notes* 2 (1935).
(9) Myers, O. H. "Cemeteries of Armant II and a Saharan culture." *Egypt. Explor. Soc.* (in preparation).
(10) Tilho, J. "Explorations of Tibesti, Erdi, Borkou, and Ennedi." *Geogr. J.* 56 (1920) 81–99, 161–183, 241–267.
(11) Noel, P. "Etude éthnographique et anthropologique sur les Tédas du Tibesti." *Anthropologie, Paris*, 3 (1920).
(12) Bouilliez, M. "Notes sur les populations Goranes." *Anthropologie, Paris* 24 (1913).
(13) Rottier. "Le Sahara oriental." *Afr. franç.* 1924 *Ren. Colon.* 1, 2, 3.
(14) Ballif, L. "Le Tibesti 1913–14." *Afr. franç.* 1921 *Ren. Colon.* 3.
(15) Réquin, Lt. "Les clans Téda du Tibesti." *Afr. franç.* 1935, Jan. Apr.
(16) Behm, E. "Das Land und Volk der Tebu." *Petermanns Mitt.* 2 (1862–63).
(17) MacMichael, H. A. 'Tribes of northern and central Kordofan.' Cambridge, 1912.
(18) Seligman, C. G. "Some aspects of the Hamitic problem in the Anglo-Egyptian Sudan." *J. R. anthrop. Inst.* 43 (1913).
(19) Lavit. "La colonie du Tchad en 1923." *Afri. franç.* 1924 *Ren. Colon* 3.
(20) Bagnold, R. A. 'Libyan Sands.' London, 1935.
(21) Slatin, Sir R. C. 'With fire and sword in the Sudan 1879–95.' London 1896.
(22) Winkler, H. A. "Rock-drawings of southern Upper Egypt I." *Egypt. Explor. Soc.* 1938.
(23) Winkler, H. A. "Rock-drawings of southern Upper Egypt II." *Egypt. Explor. Soc.* 1939.
(24) Peel, R. F. "Rock-paintings from the Libyan Desert." *Antiquity* December (1939) 389–402.
(25) Authier, D. "Ethnographie et anthropologie des Toubbous du Tibesti et du Borkou-Ennedi." *Anthropologie, Paris* 30 (1920) 577–78.
(26) Chasseloup Laubat, F. de. 'Art rupestre au Hoggar.' Paris, 1938.

(27) (*a*) Joleaud, L. "Gravures rupestres et rites d'eau en Afrique du Nord." *J. Soc. Afric.* (1933) 197–282. (*b*) "Histoire de la formation d'un désert: palaeographie du Sahara" (in 'La vie dans la region désertique nord tropicale de l'ancien monde.' Paris, 1938).
(28) Breuil, H. Quoted in Joleaud 27 (*a*).
(29) MacMichael, H. A. "Notes on the Zaghawa and the people of Gebel Meidob." *J. R. anthrop. Inst.* 42 (1912) 288. 'History of the Arabs in the Sudan.'
(30) Sabatini, A. "Anthropologie der Tebu von Kufra." *Z. für Rassenkunde* 3 (1936) 253–269.
(31) Le Coeur, Ch. "Le Tibesti et les Téda." *J. Soc. Afric.* 5 (1935) 41–46.
(32) Rottier. "Une Mission au Tibesti." *Afr. franç.* 1928 *Ren. Colon.* 7.
(33) Arkell, A. J. "Mani magic in northern Darfur." *Sudan Notes* 19 (1936) 317.
(34) Loefler. "La pacification du Tibesti, 1913–14." *Afr. franç.* 1916 *Ren. Colon.* 7.
(35) Carbou, H. 'La region du Tchad et du Ouadaï.' 1912.
(36) Keane, A. H. 'Man past and present.' Cambridge, 1920.
(37) Herodotus. Histories IV. Trans. A. D. Godley, London, 1921.
(38) Sergi, S. "The Garamantes of Libya." *Reports of 1st Congress of Ethnology and Anthropology*. London, 1934.
(39) Vaufray, R. "Le désèchement du Sahara à l'époque historique." *Anthropologie, Paris*, 45 (1935) 215–6.

REVIEWS

ASIA

THE URGE TO THE SEA: the course of Russian history, the rôle of rivers, portages, *ostrogs*, monasteries, and furs. By ROBERT J. KERNER. *Berkeley: University of California Press*, 1942. 9×6 *inches;* xviii+212 *pages; illustrations and maps.* 15*s*

This is a most complete account of how the river systems of Russia and Siberia, interconnected by the many portages, determined the course of history, but our author need not have written as if no one before him had laid stress on this governing factor. Surely no one studying Russia can have failed to be aware of its fundamental importance. Perhaps it is the first time that the matter has been treated in such detail in English, and it would be hard to find an account of how the Russian secured the nodal points, points of with we read every day in the papers, by building *ostrogs* (wooden forts), organizing defensive lines, and using monasteries as centres of cultural influence. This is illustrated by many maps, almost too many, as it is a little difficult to get one's bearings in the sectional maps, whereas those covering a great extent are on too small a scale. An interesting observation is that whereas the Franco-English portage implies canoes that could be carried from river to river, the Russian *vólok* means the dragging of big boats across. Another new point is the clear mapping of the regular trails used by the Tartar raiders to penetrate Muscovy by following the watersheds, but to call them *chaussées* as if they had been paved, is curious. That the attraction which tempted the Russian explorers was the quest of furs is a familiar fact: the author might have mentioned that this fur trade must go back

long before the Russian period, as nothing else accounts for the wealth of silver plate, Byzantine and Sassanian, found in the Perm district.

Appendixes taking nearly half the book give official lists of portages, *ostrogs*, and monasteries taken from Russian records. A strange thing is that no reference is made to John Baddeley's 'Russia, Mongolia, China,' which so magnificently covers much of the ground. The transliteration follows the Congress Library system, but it is simplified for typographical convenience, with very bad results, *e.g. i* is used both as a vowel and as a consonant or sign of softness, so that we get *kompanii i deistvii*, and nothing to tell the reader that the first word is four syllables and the last only two. E. H. M.

SHARAF AL-ZAMĀN ṬĀHIR MARVAZĪ on China, the Turks and India. Translated and with commentary by V. MINORSKY. (J. G. Forlong Fund, vol. 22.) *London: Royal Asiatic Society*, 1942. 9½×6 *inches;* 170+54 *pages*. Arabic text. 15*s*

In 1937, Professor Minorsky tells us, an almost complete copy of an Arabic manuscript entitled 'The natural properties of animals' was discovered in the India Office Library. The author, al-Marvazī—the man of Marv—was a Persian court physician, his life covering the latter half of the eleventh century and the first two decades of the twelfth. To his treatise on zoology he prefixed a section on Mankind, and it is from this section that certain chapters of special geographical interest have been chosen by the editor for reproduction, translation, and commentary. As was customary, Marvazī borrowed fully from his predecessors, and in particular from a lost work of Jayhānī belonging to the early part of the tenth century. In the long and vivid description of China there is much that is new, both geographically and historically, including a "unique report on the embassy from the K'itan emperor of Northern China to the court of the conqueror of India, Sultan Mahmūd (A.D. 1027)." The notices of remote Siberian and Arctic Russian tribes are also full of interest, especially the references to ski-ing and the use of dog-sledges. Marco Polo, it will be remembered, heard vague reports of the Far North, and of either ski-ing or skating, and the sort of intercourse that can be deduced from these reports might quite well go back to Herodotus's day and lie behind his stories of lands and peoples beyond Scythia. Another subject upon which Marvazī throws fresh light is that of the great migrations along the grassland belt. He shows how the impact of events in China, like a blow struck on the end ball of a line of billiard balls, caused movement and disturbance thousands of miles away in south-eastern Europe. This occurrence is assigned by the editor to the period A.D. 1035–50, and it is noteworthy that the struggle for sufficient pasture-land is said in the text to have been the primary cause of the movement. As befits a physician, Marvazī is a disciple of Hippocrates and Galen, and a firm believer in the importance of the physical environment in determining the characteristics of all animals, including man. It is from this point of view that the Turks as a northern people are compared with the negroes of Ethiopia and Zanj, *i.e.* tropical East Africa. It is because of the heat, which "expands the things and opens them," that the blacks "are always found to be gay, playful and laughing."

Professor Minorsky is an orientalist writing for fellow orientalists, and his profound and scholarly notes, directed often to problems of philology, are likely to be daunting to the general reader, who should at first confine himself to the translated text. Chinese, Russian, and Indian scholarship are all laid under contribution, and the editor is now at work on the complete manuscript, including the major section dealing with "dumb animals." This glimpse of medieval Asia is an exciting one. E. G. R. T.

CENTRAL AND SOUTH AMERICA

THE DISCOVERY OF YUCATAN. By FRANCISCO HERNANDEZ DE CORDOBA. A translation of the original texts with an introduction and notes by HENRY WAGNER. *Berkeley, California: The Cortés Society*, 1942. 7×10 *inches;* 85 *pages; maps*

It is pleasant to find, in these days of war preoccupation, that the Cortés Society of California, and the Quivira Society of New Mexico, have been able to publish volumes, dealing with original documents, that will assist students of the history of the New World.

The Cortés Society specializes in manuscripts of the period of discovery and conquest of what is now Latin America, and the new slim but interesting book gathers together all the known evidence concerning the voyage of Hernández de Córdoba. The material is slight, consisting of a brief letter sent to Spain in 1519; Peter Martyr's account, of 1520; evidence given at a legal inquiry in Mexico in 1522; and the eyewitness account of Bernal Diaz del Castillo, included in his 'History of New Spain' and familiarized to us already by the spirited translation of Maudslay, published by the Hakluyt Society.

The expedition of Hernández de Córdoba was small, brief, and disastrous. It was planned from Cuba, where labour for Spanish enterprises was running short, with the object of kidnapping natives from small islands off the Honduran coast; but, going farther afield, Yucatan was reached and two large Maya towns visited, Campeche and Champotón. This was the first time Europeans had beheld populous cities of stone-built dwellings and temples in the New World. The Maya however already knew something of Europeans, for Spanish and Portuguese castaways were found living with them; and their reception of Hernández and his companions at Champotón was hostile. Many Spaniards were killed, the rest embarked with difficulty, and the leader reached Cuba only to die of his wounds.

Mr. Wagner's work of translation and annotation is admirably painstaking, but he is not always happy in his diction. Rigid following of Spanish texts does not necessarily entail clarity. The documentation is excellent. L. E. J.

THREE NEW MEXICO CHRONICLES: the Exposición of DON PEDRO PINO, 1812; the Ojeada of LIC. ANTONIO BARREIRO, 1832; and the additions by DON JOSE de ESCUDERO, 1849. Translation with introduction and notes by H. BAILEY CARROLL and J. VILLASANA HAGGARD. *Albuquerque, New Mexico: The Quivira Society, Publications, vol. XI*, 1942. 6½×10 *inches;* xxxii+342 *pages; plates and maps*

This considerable volume contains for its major part a survey of the province of New Mexico, published in Cadiz in 1812 when Don Pedro Pino, wealthy landowner of Santa Fé, had gone to the Mother Country as representative of this interior and neglected region.

At the time of Don Pedro's journey, New Mexico, in company with all New Spain, was still in Spanish possession, although the "shadow of the Corsican," and reverberations of the Independence idea, had begun to affect mutual relations; twenty years later, when Barreiro published his 'Glance' at New Mexico, Spain had lost her colonies in the New World; and in 1849, when Escudero added his notes to the material of the two former works, New Mexico, together with sister provinces, had come under the flag of the United States.

The editors present evidence that the worthy Don Pedro Pino did not write the Exposición himself, but that the survey was put into shape for publication

by a well-known author and editor, Cancelada; it is however clear that t
information came from Don Pedro, the native son of New Mexico, who enjo
on his return after three years abroad the distinction of being the only N
Mexican who had ever gone to Europe. Don Pedro was able to say, in sugge
ing help for his province, that it contained no college or good public schoo
that it had no bishop, and so few clerics that marriages, deaths, and the birth
children were not attended properly by the rites of the church, although lar
tithes were paid; there were no physicians, surgeons, or pharmacists; and cri
was never punished, since there were no adequate legal systems and no jails.

According to Don Pedro, trade was with Chihuahua, forty days' journe
travellers had to carry food and water through wild country beset with dang
from hostile "Indians"; other commerce was of course forbidden by the old
rigid laws of Spain. In 1832 however Barreiro reports that caravans came
Santa Fé once a year from the United States, crossing the "horrible wilderne
of over 600 miles between New Mexico and Missouri. Until the railway ca
travellers would probably still have followed Pino's route for Europe—g
leagues across Mexico to Vera Cruz before embarking on another 1900 leagu
of sea travel.

Some of the most interesting pages refer to the native tribes of New Mexic
some of whom lived nomad lives, hunting and following the great herds
buffalo still living on the prairies; others, as the Navajo and "honourab
Comanche" folk, had made peace with the Spaniards, taken to agriculture, an
lived in settled communities. Many tribes living long before the Conquest
highly organized *pueblos* had never been greatly interfered with, nor had tri
to trouble the Europeans; Barreiro's account of the communities of Acom
Zuñi, and their like, supplementing Pino's tribute to their qualities, migh
almost have been written yesterday.

Photostat reproductions of Pino's and Barreiro's books are included in th
present volume; and the editors have performed their task of annotation wit
painstaking skill. L. E. J.

MANY A GREEN ISLE (West Indies). By GLANVILLE SMITH. *London: John
Lane*, 1942. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches;* 286 *pages; illustrations and end-paper sketch-
maps.* 15*s*

Mr. Glanville Smith is no geographer. Nor is he one of the statistically minde
who pay calls on governors and ask searching questions. He does not sniff
the facts such travellers collect; he merely wishes that he had their nerve. He
a tombstone draughtsman from Cold Spring, Minnesota, with a taste for music
a predilection for cheerful company, and a passion for islands. Like most of us
he dreams of a Utopian island of his own; meanwhile he finds refreshment
writing of the islands he visited in the Caribbean.

He is more interested in people than in things. Occasionally he will fling hi
reader a scrap of history or vividly describe a scene; but he is as erratic as a boy
pursuing a butterfly, and he demands the licence of the essayist. He has no
colour prejudice and he is at his best when describing the humbler people of the
islands. He enjoyed their music, and joined in their songs and dancing; and
being himself modest and unaffected he had the knack of making friends with
them. He realizes that, in crowd or solitude, the precious gift is the knowledge
that life runs through the rest of creation as actually as through oneself, and
that if a willingness to be pleased is happiness's first requisite, the first requisite
of festivity is a willingness to be gay. So it was that by identifying himself with
the people whom he met during his year's sojourn in the islands "the tombstone-
man," as he called himself, received their confidence; thus he has been able to

interpret them to others more intimately than a serious observer of the social scene. "God's bounty is often bestowed on those who neither sue for it nor deserve it," he says. It may be that he has deserved it better than he knew; and although some readers may find his inconsequence somewhat maddening, others will thank him for a cheerful and engaging book. O. R.

POLAR REGIONS

ULTIMA THULE: further mysteries of the Arctic. By VILHJALMUR STEFANSSON. *London: Harrap*, 1942. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches;* 256 *pages; illustrations and sketch-maps.* 10*s* 6*d*

Mr. Stefansson has done useful service by popularizing the notion of a 'Friendly Arctic,' and has written a dozen or more books touching upon various aspects of this theme. In the present volume this same thesis is again ardently propounded, although with more vigour perhaps than deep learning. The book is in three parts, entitled respectively: Pytheas and Ultima Thule, Did Columbus visit Thule?, and Were Pytheas and Columbus right about Arctic climate? The author would have us believe that not only did Pytheas in his Massilian ship sail from northern Scotland to Iceland in six days, but that he sailed round the island to its north-west or alternatively north-east extremity, and thence proceeded to visit and examine the edge of the ice-pack. Britons had already colonized Iceland and "encouraged by the customary Massilian gifts and promises, the natives would willingly agree to act as pilots on the northward voyage." After this we are not surprised to learn that Columbus's alleged voyage to Iceland is accepted as authentic, and that Mr. Stefansson believes him to have penetrated even farther poleward than Pytheas, sailing in a north-easterly direction and reaching Jan Mayen. The Juan de la Cosa map is alleged to contain a record of this voyage, imparted by Columbus to his pilot, for it shows Illa Tille (Jan Mayen) and also a Frislanda (Iceland). Tille has four conventional indentations on its four coasts (it is rectangular), and this is interpreted as a representation of the "wasp-waist" of Jan Mayen; the fact that Tille is drawn almost as large as Frislanda being explained away. Arguments from contemporary maps are, of course, worthless unless the whole range of such maps is examined. A duplicate Iceland (Friesland or Fixland) began to appear on fifteenth-century maps as Atlantic voyages multiplied, and reflected the combination of scientific and literary sources, that is of sea-charts with classical tradition. A point which Mr. Stefansson stresses in his arguments is the interpretation by Miss McCaskill of the "high-tides" mentioned by Columbus as "high seas," *i.e.* immense waves. It is interesting to note that the same suggestion is made by Professors Cary and Warrington about the great rise and fall of the sea to the north of Scotland mentioned by Pytheas. Actually, in the absence of actual measurements exaggerations of height are normal and need not be explained away. The coincidence of interpretation is however a reminder that Columbus had quite conceivably drawn upon Pytheas for authentic details with which to build up a picture of a far northern voyage which never took place. Even were we to concede both Icelandic voyages as a practical possibility, there would still remain the difficulty as to how they were financed and equipped. Pytheas's mission to Britain was an economic one, while Columbus, if he really travelled from Bristol to Iceland, can only have done so in a commercial capacity, for he was then without resources. How then did he secure ship, stores, and crew for a purely "scientific" Jan Mayen voyage?

Turning to the third part of the book, it consist mainly in an indictment of modern geographers, and Professor Trewartha in particular, for having made

up their minds on theoretical grounds about the climate of the Frigid Zone, r
refusing to listen to "the man who has been there." "The grounds upon wh
climatologists like Trewartha" (writes Stefansson) "reject travellers like D
are, but for refinement, the same as the grounds upon which geographers l
Strabo rejected the yarns of travellers like Pytheas." Against the climatologi
mean temperatures however the author sets extremes, against shade te
peratures sun temperatures, against a statement relating to Arctic Regions
general statements relating to locations with a high degree of "continentali
within the Arctic Circle. Professor Trewartha's explanation that "much of t
solar energy is reflected by the snow and ice" is paraphrased as "the sunbea
are light and not heat, and . . . much of the light is not converted into h
because it is reflected by the snow." Atmospheric absorption is deemed a m
device of the climatologists to bolster up their case, and the author prefers t
Elizabethan commentator George Best as an authority. His competency
enter into climatological argument may be judged from the following quotati
"We understand it as a principle, and we know it through innumerable repor
that the winter, though less cold over the northern sea than over the land j
to south of it, is nevertheless able to store in the sea a chill which is releas
during the summer." Neither as historian or scientist can Mr. Stefans
carry any weight, but the "man who has been there" can and does fulfil impor
ant functions. Especially in the case of climatologists is it true (as they wo
be the first to confess) that the accepted practice of presenting normals a
means, valuable though it is for theoretical purposes, is not helpful to the ge
grapher, the agriculturalist, or the economist, still less to the ordinary pers
The new notations which express variability and deviations from the mean a
all too little used, chiefly, of course, because of the immense labour required
re-compute existing meteorological data. To Mr. Stefansson and no doubt
some of his readers, climatology and cosmography do not square with comm
sense and they feel that indignation and repudiation are justified. "It is wh
we learn in the common school geography courses," writes the author, "th
shapes the geographic thinking of most of us." And this is only too appare

E. G. R. T

PHYSICAL AND BIOLOGICAL GEOGRAPHY

INTRODUCTION TO METEOROLOGY. By SVERRE PETTERSSEN. *New York and London: McGraw-Hill Book Co.*, 1941. 9×6 *inches;* x+236 *pages, maps and diagrams.* 17*s* 6*d*

This book is essentially an abbreviation, simplified by the omission of calcul
of the author's major work, 'Weather analysis and forecasting' (*Geogr. J.*
(1942) 105) setting forth the principles of air mass analysis developed by t
Norwegian school of meteorologists. As such it is highly successful, a
nowhere will the student find clearer explanations of the physical characte
istics of different types of air mass, the structure of depressions, and the diffic
conceptions involved in the thermo-dynamics of the atmosphere includi
temperature lapse-rates, moist and dry, and entropy-temperature relationsh
The very fact however that the work is specially designed for the use of fo
casters and aviators means that it will not succeed so well in the avowed aim
attracting the general reader to meteorology. For this purpose many anoth
modern book is more suitable. The exposition is lucid and the diagrams mo
original than in many books, but some subjects receive very scanty treatme
and no appeal is made to the reader's aesthetic sense in accounts of clouds a
other phenomena of the atmosphere in relation to the landscape.

The least satisfactory chapters are the last two, Climate and History. The wide field of climatology is condensed into a single chapter too much of which is spent upon an elaboration of Köppen's scheme of classification of climate and the general treatment is somewhat out of date and commonplace with little reference to interesting questions exercising climatologists to-day, such as consideration of climatic peculiarities and anomalies of particular regions, and the physiological aspects of climate including wet-bulb temperature. The concluding chapter on history has an appearance of having been hastily compiled to provide ballast. Much of it consists of a string of names and dates, and general obscurity culminates in the following statement: "In 1624 the rotation of the winds with the sun was discovered by von Verulam." Presumably this implies that Lord Bacon discovered a not very pronounced tendency for the wind in fine settled weather to veer round during the day from east to west.

There are good photographs of clouds, numerous charts, and a useful set of conversion tables at the end of the volume. L. C. W. B.

CARTOGRAPHY

KARTY I ATLASY (MAPS AND ATLASES). By N. V. VINOGRADOV. Edited by M. S. BODNARSKI and M. P. MURASHOV. (In Russian.) *Moscow: Academy of Sciences*, 1941. 9×7 *inches;* 192 *pages; illustrations, sketch-maps, and diagrams.* 7.50 rubles

'Karty i Atlasy' is a text-book on maps intended apparently for University students and the general public. It includes chapters on projections, scales, conventional signs (with a list of those used on modern Russian maps), and lettering with some account of the problems of transliteration, the expression of relief, grids, the preparation of maps from the point of view of assembling and selecting the material, constructing the geometrical foundation and the actual processes of production, but does not touch surveying or geodesy. After a chapter on map reading, much attention is given to the subject of special maps for facts, physical, natural history, and economic, and ingenious means of presenting them.

The treatment of atlases gives a historical account of their development with the devices adopted to improve various modern atlases, followed by a survey of the more important, but there is not much information about series of maps. An interesting account of Russian mapping and atlas-making leads up to a full description of the Great Soviet World Atlas, on which the author worked. The theme running right through is that not too much can be expected in capitalistic countries, whose work will be entirely outclassed by Soviet cartography. There is however a pretty good survey of non-Russian atlases, and due credit is given to British achievement, though the great German atlases are given the first place in spite of their clinging to hâchures instead of layering. A chapter on the history of cartography largely repeats what has been said of the development of atlases. There is a fair account of the 1/M map, with a figure showing its position in 1938. In 1940 the central office for Geodesy and Cartography of the U.S.S.R. started to make a 1/M map of the whole U.S.S.R. "with the international disposition and conventional signs close to the international model but modified to suit the national economy of a socialist state."

An amusing example of the difficulty of recognizing Chinese names in Russian is afforded by the account of the Shun Pao Atlas, Shanghai, 1934, the authors known to us as V. K. Ting (Ting Wên-Kiang), W. H. Wong (Wêng Wên-hao), and S. V. Tseng appearing as Din-Ven-Dzyan, Ven-Ven'-Khkho, and Tsven Shi-Gen. E. H. M.

THE MONTHLY RECORD

ADDITIONS TO THE LIBRARY

The Panamerican Institute of Geography and History began last year t
publication of a *Revista Geografica*. The combined number for May
December contains a preliminary scheme of the physiographical regions
Mexico by E. Ordoñez and an account by F. K. Millerreid of late Pliocen
volcanoes in the east of Coahuila, the most north-easterly extension of th
activity in Mexico. Each number contains annotated bibliographies whi
should be particularly helpful to students of Latin American geography. T
geographical societies of Quebec, reconstituted after a suspension in 1933,
of Montreal, founded in 1939, are publishing jointly a *Bulletin*, the first numb
appearing in January of this year. The principal contents is an analysis of t
structure and relief of the five major Canadian regions, prepared for use
schools by B. Brouillette. In the first part of an article on the share of gover
ment in economic development, R. Belisle urges that the province of Queb
requires the expert investigation of her communications, especially po
facilities, the provision of cheap hydroelectric power, and the encouragement
industrial research.

A special number of the *Boletin* of the geographical society of Lima (vol. 5
1942) commemorates the fourth centenary of the first descent of the Amaz
by Orellana. Besides appropriate historical studies, there are papers on t
opening-up of the Peruvian Oriente, E. Delboy dealing with Iquitos and i
prospects, and L. M. Gamio with routes from the west into the upper basi
Iquitos, despite economic vicissitudes, has at present forty thousand inhab
tants: its future depends upon the development of local forest and pla
resources, both for export and for its own food supplies, and especially on t
improvement of communications. By the end of this year it is anticipated th
there will be a through road from Lima *via* Huanuco and Tingo Maria
Pucallpa on the Ucayalí, whence there is a regular river service to Iquitos.
the north another road is being built which will give access from the Paci
coast through Olmos and Jaén to Bellavista on the Marañon. This road cross
the Cordillera by the relatively low pass of Abra de Porculla, 2150 m. T
Boletin of the Madrid Geographical Society resumed publication last year.
the last number received there is an account by M. García Lloréns of a rec
natural history expedition to Spanish Guinea, and a geological map of t
colony. G. Garcia Badell also contributes a detailed study of the size and di
tribution of agricultural holdings in Spain, and suggests policies for ru
reconstruction. One of the chief problems is the extreme subdivision of t
smaller properties. Seventy-five per cent. of all separate parcels of land are le
than 1 ha. in size, and comprise 11·9 per cent. of the cultivated area: in contra
those over 100 ha. are 0·33 per cent. of the total number, but account for 45
per cent. of the area. In one instance quoted, Almonacid de Zorita, Guadal
jara, 4571 ha. of land are divided into five thousand five hundred and fifty-thr
lots, distributed among six hundred and twenty-one proprietors. The writ
urges the completion of the cadastral survey, to permit the initiation of co
solidation schemes. The general problem of the consolidation of agricultur
holdings and the progress attained in various European countries are examine
by M. Tcherkinsky in the *International Review of Agriculture* for March 1942.

THE HYDROLOGY OF LAKE SUPERIOR

The catchment area of the Great Lakes looks so small compared with th
lakes themselves as to make one ask how it can supply all the water which com

ch year over the falls of Niagara. The most recent study of the question is by Symposium of the American Society of Civil Engineers, published in their roceedings for 1939. In the number for April 1939 (vol. 65, No. 4) Colonel R. Pettis, of the Corps of Engineers, U.S. Army, has an important paper on Typical quantitative analysis as applied to Lake Superior," and Mr. Harold Hickman gives an account of his "Evaporation experiments." Subsequent umbers for the year contain criticisms of their results. A brief account of all is work will interest those who read Mr. Kanthack's paper on "The hydrology Lake Nyasa" (*Geogr. J.* July 1941).

Colonel Pettis' investigation is based on observations for the fifteen years 20–34. The average annual rainfall on the land surface of the catchment area Lake Superior, 49,078 square miles, was determined as 28·2 inches, from fty-nine stations of the U.S. Weather Bureau whose distribution is not given: ere is no mention of observations from the Canadian part of the area, nor are e told if a proper number of the fifty-nine stations are near the indefinite atershed rising to about 1000 feet above the lake surface. Stream gauging vers about half the area and gives a run-off estimated at 11·6 inches for the hole. The land-loss by evaporation from the surface or by transpiration rough vegetation, and the underground flow from springs into the lake, are antities which cannot be gauged and appear as unknowns (indicated by alics) in the equation:

Land rainfall 28·2 inches = Run-off 11·6 inches + *land-loss* + *underground flow* (1)

The lake surface is 31,817 square miles or 1/1·54 of the land surface of the tchment area. The rainfall on the lake is assumed the same as that on the nd, since the evidence of some difference is conflicting. The change of rage in the lake is determined by the gauges of the U.S. Lake Survey, but o figures are given. The outflow from the lake by St. Mary's River, 27·0 inches er the lake surface, is based on records of the U.S. Engineer Department. he equation for the lake is:

Lake rainfall 28·2 inches + (run-off 11·6 and *underground flow*) × 1·54 = outflow 7·0 inches + change of storage, assumed to average out over the fifteen years, *evaporation* (2)

We have then two equations between eight quantities, of which four are irly well measured; one is assumed zero in the mean; two, underground flow d land loss, are unknown; and the evaporation, very doubtfully determinable gauging, is treated as a third unknown.

Colonel Pettis assumes that the normal open-water evaporation curve for onthly periods will be approximately a sine curve with period one year, with aximum in mid-winter, when the lake is warmer than the air. Divergences om this curve are due to partial freezing of the lake, and to land loss. By a rocess of reasoning which is too detailed to summarize, he deduces from the onthly figures an annual value 5·9 inches for land loss.

Transforming the second equation by substitution from the first, we have en for the average year:

Evaporation + land-loss × 1·54 = 44·5 inches (3)

Substituting 5·9 for the land loss he finds 35·6 inches for the annual evapora- on, which is a little less than the figure found by Mr. Hickman from his periments with evaporation pans in which the water is kept more or less at ke temperature. And by substituting this value of land-loss in the first equa- on he makes the underground flow 10·7.

Colonel Pettis thus concludes that the evaporation and the underground flow e greater and the land losses less than the values that have been generally

accepted. His critics, in contributions to the Symposium published d
1939, support the conclusion that evaporation is greater in winter th
summer, as in accordance with Dalton's law; they consider the lan
improbably low, both because the land area is itself full of lakes, and a
comparison with results obtained elsewhere in the States, between 1
20 inches; and they point out that the area is underlain by crystalline
generally impervious, that the water-table slopes generally towards the st
and not towards the lake, and that usually in large drainage basins of the U
States the subterranean flow is small. Earlier results for the lake evapo
were 22 inches, 15 inches, and 23 inches.

If land-loss is Colonel Pettis' 5·9, his evaporation is 35·6 by (3); if it
raised to 14 inches, evaporation would be 23·4, in close agreement wit
23 inches of Hayford and Folse (1930); and the underground flow wou
2·6 inches instead of 10·7 from (1). Further, for every inch the average r
has been underestimated the evaporation would come out 2·54 inches gr
If, as seems possible, the data used by Colonel Pettis come from observ
at U.S. stations only, it is most desirable they should be extended to cov
whole catchment area.

It is clear from this Symposium that it is difficult and costly, perhap
possible, to measure evaporation over a great lake surface, partly froz
winter when evaporation from whatever surface remains open is a maxi
but that the equations naturally give lake evaporation plus land loss, *i.*
sum of evaporation plus transpiration over the whole catchment area. A
it is difficult, and perhaps unnecessary, to distinguish between visible r
and underground flow, but the equations naturally give the sum of the
which is the land's contribution to the lake. Then everything depends o
measurement of rainfall and outflow, whose accuracy, here assumed,
require more critical examination.

Colonel Pettis' paper is part of a thesis 'Hydrology of the Great Lakes,'
mitted to the University of Michigan in 1938, and a copy including all ob
tions and data is in the Engineering Society's Library, 33 West 39th S
New York. So far as we can learn, no summary of the results for the other
has yet been published. It would be very interesting to have it, for ther
be nowhere in the world so great possibilities of studying these impo
questions as in these great lakes, well provided with rain, level, and ou
gauges, but complicated by the snow and ice of severe winters. We hop
Colonel Pettis may find time, even in these busy days, to publish at leas
principal figures of his results for the other lakes. A. F

ELECTIONS

The following have been elected Fellows of the Society:

On July 13: The Rev. L. A. Duprez; Professor W. M. Fouts, B.A., T
TH.D.; Lieut-Commander G. C. H. Hamilton, R.N.V.R., B.A., LL.B.; 2/L
J. Hartog, Royal Signals; The Rev. Basil Holt; E. C. Lester; Miss E. Nicho
H. S. Stovold, M.A.

On July 20: E. P. Boon, M.SC.; S. L. Davison; 2/Lieut. H. Fullard, R.E.;
Nsa Eyo Nkune; Mrs. M. L. Sheddick, B.SC.; George Douglas Scott Woo

10°
20°
MEDITERRAN
Sicily
Malta
Tripoli
Homs
Misurata
Bengasi
Zuara
Garian
Tarhuna
Nalut
Giado
Gulf of Sirte
TRIPOLITANIA
CIREN
30°
Gadames
El Giofra
Hun
Marada
Gialo
Jes Soda
Zella
Zighen
L I B
FEZZAN
Murzuch
Ubari
Gat
Ulau el Chebir
Ulau en Namus
In Ezzan
Tummo
TEDA
TÉDA
Djado
Bardai
Sarra
20°
Bilma
FR W AFRICA
KANURI
BORKOU
GAEDA
BODELE
FR EQ AFRIC
L. Chad
KANEM
GURAAN
KRÉDA
OUADAI
KECHERDA
BORNU
10°
20°

Areas

---- Ap

LIBYA: TIBU PEOPLES
Peel

Areas inhabited by Tibu and related peoples
(names of peoples in red.)

Approximate limit of Tibu zone